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(71) Applicant and
(72) Inventor: **NAGAOKA, Tadayoshi** [JP/JP]; 573-2, Oaza Ureshi, Tondabayashi-shi, Osaka 584-0056 (JP).

(74) Agents: **SAKAMOTO, Tohru** et al.; Sakamoto Harada Tokkyo Jimusho, Doho Building, 18-6, Nishishinbashi 1-chome, Minato-ku, Tokyo 105-0003 (JP).

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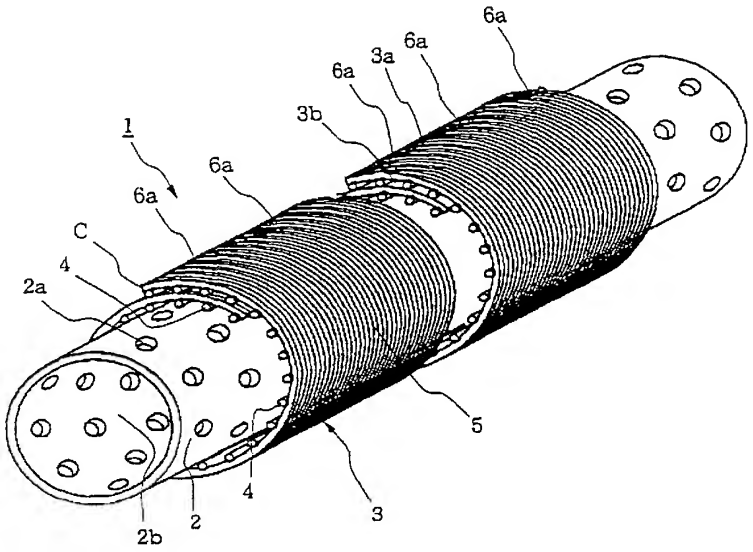
(54) Title: EXPANDABLE SCREEN FOR A HORIZONTAL OR HIGH-ANGLE WELL AND METHOD FOR INSTALLING THE SAME



(57) Abstract: An expandable screen for a horizontal or high-angle well includes: a perforated base pipe (2) formed with a multitude of liquid collection holes (2a), a spiral wedge-wire screen (3) including a plurality of support rods (4) and a spiral wedge wire (5) wound about the support rods on the outer peripheral side of the support rods to form a slit (5a) of a predetermined width and being welded to the support rods. The spiral wedge-wire (5) is cut in the axial direction of the screen at a point (C). The spiral wedge-wire screen (3) is wrapped on the perforated base pipe (2) and end portions (3a, 3b) of the spiral wedge-wire screen (3) are superposed one upon the other thereby urging the spiral wedge-wire screen to expand, and the end portion (3a) is connected to a portion (3c) of the spiral wedge-wire screen (3) by means of connecting wires (6).

WO 03/100211 A1

DESCRIPTION

Expandable Screen for a Horizontal or High-angle Well and Method for Installing the Same

Technical Field

This invention relates to a well screen for a horizontal or high-angle well and, more particularly, to a well screen for a horizontal or high-angle oil well capable of preventing movement of sand grains accompanying crude oil flowing into the well.

Background Art

There has recently been an increasing tendency in the field of a well for collecting crude oil to substituting a conventional vertical well formed by digging the ground vertically from the ground surface to the oil stratum by a horizontal or high-angle well. FIG. 32 shows one of such horizontal or high-angle well 100 which is formed by digging the ground from a vertical portion 100a through a curved portion 100b to a horizontal or high-angle portion 100c which extends in the horizontal or inclined direction along the oil stratum. Since this type of horizontal or high-angle well has a screen section for collecting oil which is several time as long as a conventional vertical well, the horizontal or high-angle well has the advantage that it has a superior production efficiency which is several times as large as that of the vertical well.

In the oil well, the crude oil stratum very often depends upon a sand stratum. There is generally a large gap between a well bore and a cylindrical screen and, when crude oil flows into the well, sand grains flow out of the oil stratum with crude oil and collide with the slit portion of the screen.

Collision of sand grains with the screen causes erosion of the screen wire as the screen is used over a long period of time with the result that the screen ceases its proper function of preventing sand grains from entering in the screen.

For preventing such erosion of the screen wire, a general practice adopted in the industry is, as shown in FIG.33, to fill gravel 140 in an annulus between a well bore 120 and a cylindrical screen 130 so that when crude oil flows into the well in the direction of the arrow B, sand of the oil stratum does not move and therefore does not collide with the screen wire.

In a horizontal or high-angle well, however, no technique has been developed yet for filling gravel in a gap between a well bore and a cylindrical screen and, accordingly, as shown in the section of FIG.34A and the section of FIG. 34B taken along lines A-A in FIG. 34A, a cavity 150 is produced in the horizontal portion 100c between the top portion of a cylindrical screen 130 and a well bore 120 and there occurs inevitable erosion of the screen due to collision with sand grains accompanying the flow of the oil in the direction of the arrow B. No effective means for preventing such invasion of sand grains into the screen after use of the screen over a long period of time has not been found yet. Further, sand grains move with the flow of the crude oil in the cavity 150 and, the well itself will collapse with lapse of time resulting in stop of the flow of crude oil.

It is, therefore, an object of the present invention to provide a cylindrical screen for a horizontal or high-angle well capable of preventing erosion of the screen due to collision of sand against the screen and preventing also collapse of the well due to movement of sand notwithstanding use of the screen over a long period of time in a horizontal or high-angle well in which filling of gravel is difficult

Disclosure of the Invention

For achieving the object of the invention, there is provided an expandable screen for a horizontal or high-angle well comprising:

a perforated base pipe formed with a multitude of liquid collection holes;

a spiral wedge-wire screen comprising a plurality of support rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire wound about the support rods on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods, said spiral wedge-wire being cut in the axial direction of the screen at a point in the circumferential direction, and said spiral wedge-wire screen having an outer diameter which is almost equal to or slightly smaller than a diameter of a well-bore in which the screen is installed and an inner diameter which is larger than an outer diameter of the perforated base pipe by a predetermined value;

said spiral wedge-wire screen being wrapped on the outer periphery of the perforated base pipe with end portions of the spiral wedge-wire screen in the circumferential direction being superposed one upon the other and thereby urging the spiral wedge-wire screen to expand, and the end portion on the outer peripheral side of the superposed end portions being connected at a predetermined interval in the axial direction of the screen to a portion of the spiral wedge-wire screen other than the superposed end portions by means of connecting wires which pass through a hollow central portion of the perforated base pipe.

According to the invention, by inserting the connecting wire cutting pipe or rod in the expandable screen installed in a predetermined location of the well bore and cutting the connecting wires one by one, the spiral wedge-wire

screen expands and covers the inner wall of the well. Accordingly, the movement of sand grains which tend to flow into the screen with crude oil can be interrupted by the spiral wedge-wire screen whereby collision of the sand grains against the screen wire can be prevented and collapse of the well can be prevented.

In one aspect of the invention, a wire-mesh is provided between the end portions in the circumferential direction of the spiral wedge-wire screen and end portions in the circumferential direction of the wire-mesh are welded to the end portions in the circumferential direction of the spiral wedge-wire screen.

According to this aspect of the invention, when the spiral wedge-wire screen is expanded, the gap produced between the end portions thereof in the circumferential direction is covered by the wire-mesh whereby flow of sand grains from outside into the screen through this gap can be prevented.

In another aspect of the invention, the spiral wedge-wire screen consists of a plurality of screen portions disposed at a predetermined interval in the axial direction of the screen and a mesh filter is provided over the outer peripheral surface of the screen portions, a gap between the end portions in the circumferential direction of the respective screen portions and the interval between adjacent ones of the screen portions.

According to this aspect of the invention, since the spiral wedge-wire screen is divided to a plurality of screen portions disposed at a predetermined interval in the axial direction of the screen, the screen can easily advance in a curved portion of the well. Further, since the mesh filter expands to even a small gap between the well bore and the wedge-wire screen and thereby

prevents movement of the sand grains more completely. Furthermore, since the gap between the screen portions is covered also by the mesh filter, flowing in of the sand grains through this gap can also be prevented.

In another aspect of the invention, there is provided an expandable screen for a horizontal or high-angle well comprising:

a perforated base pipe formed with a multitude of liquid collection holes;

an inner spiral wedge-wire screen comprising a plurality of support rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire wound about the support rods on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods;

an outer spiral wedge-wire screen comprising a plurality of support rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire wound about the support rods on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods, said spiral wedge-wire being cut in the axial direction of the screen at a point in the circumferential direction, and said spiral wedge-wire screen having an outer diameter which is almost equal to or slightly smaller than a diameter of a well-bore in which the screen is installed and an inner diameter which is larger than an outer diameter of the inner spiral wedge-wire screen by a predetermined value;

said outer spiral wedge-wire screen being wrapped on the outer periphery of the inner sprial wedge-wire screen with end portions of the outer spiral wedge-wire screen in the circumferential direction being superposed one upon the other and thereby urging the outer spiral wedge-wire screen to expand, and the end portion on the outer peripheral side of the outer superposed end portions being connected at a predetermined interval in the

axial direction of the screen to a portion of the outer spiral wedge-wire screen other than the superposed end portions by means of connecting wires which pass through a hollow central portion of the perforated base pipe.

According to this aspect of the invention, even if sand grains flow in through the gap produced between the expanded end portions in the circumferential direction of the outer spiral wedge-wire screen when the outer spiral wedge-wire screen has expanded, flowing of the sand grains into the screen can be prevented by the inner spiral wedge-wire screen.

In another aspect of the invention, a mesh filter is provided on the outer periphery of the outer spiral wedge-wire screen and end portions in the circumferential direction of the mesh filter are welded to the end portions in the circumferential direction of the outer spiral wedge-wire screen.

By this arrangement, when the outer spiral wedge-wire screen has expanded, the mesh filter is caused to expand even to a small gap between the wall of the well and the outer spiral wedge-wire screen and thereby prevent the movement of the sand grains more completely.

In another aspect of the invention, the expandable screen further comprises a plurality of skid rods made of metal rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen, said skid rods being welded to the outer periphery of the outer spiral wedge-wire screen.

By this arrangement, the skid rods perform the function of a sleigh when the screen is inserted in the well bore to mitigate friction between the outer surface of the screen and the wall of the well and, as a result, the screen

can be inserted into the well easily and smoothly and the operation time required for inserting the screen can be shortened.

In another aspect of the invention, the support rods have either a wedge-shape or a polygonal shape.

According to this aspect of the invention, when, after expansion of the wedge-wire screen and completion of installation of the screen, pressure has been applied in a direction of reducing the diameter of the wedge-wire screen by crude oil and sand grains which tend to flow into the screen and, as a result, the end portions in the circumferential direction of the wedge-wire screen slide relative to each other in an offset state, the edge of one end portion abuts against the endmost support rod provided in the other end portion and thereby prevents further relative sliding movement of the end portions of the wedge-wire screen which might damage the wedge-wire screen.

The support rods preferably have a length in the radial direction of the screen which is larger than a length in the radial direction of the screen of the outer spiral wedge-wire screen. By this arrangement, relative siling movement of the end portions of the wedge-wire screen can be prevented even more effectively.

In another aspect of the invention, there is provided an expandable screen for a horizontal or high-angle well comprising:

a perforated base pipe formed with a multitude of liquid collection holes;

a plurality of steel plates in the form of a belt rounded annularly and wrapped on the outer periphery of the base pipe at a predetermined interval in the axial direction of the screen with end portions of each of the steel plates

being superposed one upon the other thereby urging the steel plate to expand, and the end portion on the outer peripheral side of the superposed end portions being connected to a portion of the steel plate other than the superposed end portions by means of connecting wires which pass through a hollow central portion of the perforated base pipe; and

a mesh filter covering the outer periphery of a portion of the perforated base pipe between the rounded steel plates provided at both ends in the axial direction of the screen and the outer periphery of the respective steel plates, end portions in the circumferential direction of the screen of the mesh filter being welded to the end portions in the circumferential direction of the screen of the steel plates.

According to this aspect of the invention, by inserting a connecting wire cutting pipe or rod in the perforated base pipe and cutting the connecting wires, the rounded steel plates are caused to expand and the mesh filter covers the inner wall of the well and thereby prevents movement of the sand grains.

In another aspect of the invention. there is provided a method for installing an expandable screen for a horizontal or high-angle well comprising:

(1) a step of installing an expandable screen in a predetermined location in a well bore, said screen comprising:

a perforated base pipe formed with a multitude of liquid collection holes;

a spiral wedge-wire screen comprising a plurality of support rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire wound about the support rods on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods,

said spiral wedge-wire being cut in the axial direction of the screen at a point in the circumferential direction, and said spiral wedge-wire screen having an outer diameter which is almost equal to or slightly smaller than a diameter of a well-bore in which the screen is installed and an inner diameter which is larger than an outer diameter of the perforated base pipe by a predetermined value;

said spiral wedge-wire screen being wrapped on the outer periphery of the perforated base pipe with end portions of the spiral wedge-wire screen in the circumferential direction being superposed one upon the other and thereby urging the spiral wedge-wire screen to expand, and the end portion on the outer peripheral side of the superposed end portions being connected at a predetermined interval in the axial direction of the screen to a portion of the spiral wedge-wire screen other than the superposed end portions by means of connecting wires which pass through a hollow central portion of the perforated base pipe.

(2) a step of inserting into the perforated base pipe a connecting wire cutting pipe or rod having an outer diameter which is smaller than the inner diameter of the perforated base pipe and is sufficient for abutting against the connecting wires passing through the hollow central portion of the perforated base pipe when the connection wire cutting pipe or rod is inserted in the perforated base pipe and cutting the connecting wires one by one to expand the spiral wedge-wire screen.

In this method, the expandable screen may further comprise a wire-mesh provided between the end portions in the circumferential direction of the spiral wedge-wire screen and end portions in the circumferential direction of the wire-mesh are welded to the end portions in the circumferential direction of the spiral wedge-wire screen.

In this method, the expandable screen may be one wherein the spiral wedge-wire screen consists of a plurality of screen portions disposed at a predetermined interval in the axial direction of the screen and a mesh screen is provided over the outer peripheral surface of the screen portions, a gap between the end portions in the circumferential direction of the respective screen portions and the interval between adjacent ones of the screen portions.

In another aspect of the invention, there is provided a method for installing an expandable screen for a horizontal or high-angle well comprising:

(1) a step of installing an expandable screen in a predetermined location in a well bore, said screen comprising:

a perforated base pipe formed with a multitude of liquid collection holes;

an inner spiral wedge-wire screen comprising a plurality of support rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire wound about the support rods on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods;

an outer spiral wedge-wire screen comprising a plurality of support rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire wound about the support rods on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods, said spiral wedge-wire being cut in the axial direction of the screen at a point in the circumferential direction, and said spiral wedge-wire screen having an outer diameter which is almost equal to or slightly smaller than a diameter of a well-bore in which the screen is installed and an inner diameter which is larger than an outer diameter of the inner spiral wedge-wire screen by a predetermined value;

said outer spiral wedge-wire screen being wrapped on the outer periphery of the inner sprial wedge-wire screen with end portions of the outer spiral wedge-wire screen in the circumferential direction being superposed one upon the other and thereby urging the outer spiral wedge-wire screen to expand, and the end portion on the outer peripheral side of the outer superposed end portions being connected at a predetermined interval in the axial direction of the screen to a portion of the outer spiral wedge-wire screen other than the superposed end portions by means of connecting wires which pass through a hollow central portion of the perforated base pipe.

(2) a step of inserting into the perforated base pipe a connecting wire cutting pipe or rod having an outer diameter which is smaller than the inner diameter of the perforated base pipe and is sufficient for abutting against the connecting wires passing through the hollow central portion of the perforated base pipe when the connecting wire cutting pipe or rod is inserted in the perforated base pipe and cutting the connecting wires one by one to expand the outer spiral wedge-wire screen.

In this method, the expandable screen may further comprise a mesh filter provided on the outer periphery of the outer spiral wedge-wire screen and end portions in the circumferential direction of the mesh filter are welded to the end portions in the circumferential direction of the outer spiral wedge-wire screen.

In this method, the expandable screen may further comprise a plurality of skid rods made of metal rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen, said skid rods being welded to the outer periphery of the outer spiral wedge-wire screen.

In another aspect of the invention, support rods have either a wedge-shape or a polygonal shape.

The support rods preferably have a length in the radial direction of the screen which is larger than a length in the radial direction of the screen of the outer spiral wedge-wire screen.

In another aspect of the invention, there is provided a method for installing an expandable screen for a horizontal or high-angle well comprising:

(1) a step of installing an expandable screen in a predetermined location in a well bore, said screen comprising:

a perforated base pipe formed with a multitude of liquid collection holes;

a plurality of steel plates in the form of a belt rounded annularly and wrapped on the outer periphery of the base pipe at a predetermined interval in the axial direction of the screen with end portions of each of the steel plates being superposed one upon the other thereby urging the steel plate to expand, and the end portion on the outer peripheral side of the superposed end portions being connected to a portion of the steel plate other than the superposed end portions by means of connecting wires which pass through a hollow central portion of the perforated base pipe; and

a mesh filter covering the outer periphery of a portion of the perforated base pipe between the rounded steel plates provided at both ends in the axial direction of the screen and the outer periphery of the respective steel plates, end portions in the circumferential direction of the screen of the mesh filter being welded to the end portions in the circumferential direction of the screen of the steel plates.

(2) a step of inserting into the perforated base pipe a connecting wire cutting pipe or rod having an outer diameter which is smaller than the inner

diameter of the perforated base pipe and is sufficient for abutting against the connecting wires passing through the hollow central portion of the perforated base pipe when the connecting wire cutting pipe or rod is inserted in the perforated base pipe and cutting the connecting wires one by one to expand the rounded steel plates.

Brief Description of the Drawings

In the accompanying drawings,

FIG. 1 is a perspective view showing a preferred embodiment of the invention;

FIG. 2 is a cross section of the embodiment;

FIG. 3 is a partially enlarged perspective view of a spiral wedge-wire screen;

FIG. 4 is a perspective view showing the spiral wedge-wire screen in a state before cutting;

FIG. 5 is a cross section showing a state in which the screen is installed in a well;

FIG. 6 is a perspective view showing a manner of cutting connection wires;

FIG. 7 is a perspective view showing the spiral wedge-wire in an expanded state;

FIG. 8 is a cross section of the state of FIG. 7;

FIG. 9 is a cross section showing a modified example of a manner of connecting the connecting wires;

FIG. 10 is a perspective view showing another embodiment of the invention;

FIG. 11 is cross section showing the spiral wedge-wire screen in an expanded state;

FIG. 12 is a perspective view showing another embodiment of the invention;

FIG. 13A is a cross section showing the screen installed in the well;

FIG. 13B is a cross section showing the outer spiral wedge-wire screen in an expanded state;

FIG. 14 is a perspective view showing another embodiment of the invention;

FIG. 15 is a cross section showing the outer spiral wedge-wire screen in an expanded state;

FIG. 16 is a perspective view showing another embodiment of the invention;

FIG. 17 is a cross section showing the outer spiral wedge-wire screen in an expanded state;

FIG. 18A is a perspective view showing another embodiment of the invention;

FIG. 18B is a cross section of this embodiment;

FIG. 19 is a cross section showing a rounded steel plate in an expanded state;

FIG. 20 is a cross section showing another embodiment of the invention with its spiral wedge-wire screen being in an expanded state;

FIG. 21 is a cross section showing another embodiment of the invention with its spiral wedge-wire screen being in an expanded state;

FIG. 22 is a partial enlarged view of FIG. 20;

FIG. 23 is a view showing another example of a section of the support rods;

FIG. 24 is a cross section showing another embodiment of the invention with its spiral wedge-wire being in an expanded state;

FIG. 25 is a cross section showing another embodiment of the invention with its spiral wedge wire being in an expanded state;

FIG. 26 is a cross section showing another embodiment of the invention with its spiral wedge wire being in an expanded state;

FIG. 27 is a cross section showing another embodiment of the invention with its spiral wedge wire being in an expanded state;

FIG. 28 is a cross section showing another embodiment of the invention with its spiral wedge wire being in an expanded state;

FIG. 29 is a cross section showing another embodiment of the invention with its spiral wedge wire being in an expanded state;

FIG. 30 is a cross section showing another embodiment of the invention with its spiral wedge wire being in an expanded state;

FIG. 31 is a cross section of the embodiment;

FIG. 32 is a sectional view schematically showing a horizontal well;

FIG. 33 is a sectinal view showing a gravel filled state in a vertical well; and

FIGs. 34A and 34B are sectional view showing a state of disposition of a conventional screen in a horizontal well.

Best Mode for Carrying Out the Invention

Preferred embodiments of the invention will now be described with reference to the drawings.

FIGs. 1 to 9 show one embodiment of the present invention. In the perspective views showing an expandable screen, a middle portion of a spiral wedge-wire screen is omitted for convenience of illustration.

An expandable screen 1 comprises a perforated base pipe 2 formed with a multitude of liquid collection holes 2a and a spiral wedge-wire screen 3 provided on the outer periphery of the perforated base pipe 2.

The spiral wedge-wire screen 3 comprises a plurality of support rods 4 extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire 5 wound about the support rods 4 on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods 4. The spiral wedge-wire 5 is cut in the axial direction of the screen at a point C in the circumferential direction. The spiral wedge-wire screen 3 has an outer diameter which is almost equal to or slightly smaller than a diameter of a well-bore in which the screen is installed in a state in which the spiral wedge-wire screen 3 is expanded and an inner diameter (i.e.., inner diameter of the spiral wedge-wire 5) which is larger than an outer diameter of the perforated base pipe 2 by a predetermined value.

The support rods 4 constitute support members for the spiral wedge-wire 5 and are made of steel rods having a circular cross section. The support rods 4 may be made of rods of other cross section such as a polygonal cross section. The support rods 4 are disposed generally cylindrically in the circumferential direction of the screen.

On the outside surface of the support rods 4 is wound the spiral wedge-wire 5 in the direction substantially crossing the support rods 4. As will be apparent from FIG. 3, the spiral wedge-wire 5 is arranged in such a manner that its flat surface 5b faces outside and the other two sides 5c and 5d define the slit 5a with the adjacent wedge-wire portion which widens gradually radially inwardly, i.e., toward the inside of the screen. The spiral wedge-wire 5 is welded at its inside apex 5e to the support rods 4. The width of the slit 5a in the axial direction of the spiral wedge-wire 5 is so set that the width of the slit 5a at the same plane as the outside surface of the spiral

wedge-wire 5 will become smaller than the width of the outside surface of the spiral wedge-wire 5.

The spiral wedge-wire screen 3 can be obtained by, as shown in FIG. 4, forming a normal wedge-wire screen 3' and cutting it in the axial direction of the screen at a point C in the circumferential direction. In this and subsequent embodiments, the width of the slit of the spiral wedge-wire is preferably set at a proper value within a range from 0.1mm to 3mm.

The spiral wedge-wire screen 3 wrapped on the outer periphery of the perforated base pipe 2 is elastically deformed by forcibly superposing end portions 3a and 3b in the circumferential direction of thereof one upon the other thereby urging (energizing) the superposed end portions 3a and 3b to expand. The end portion 3a on the outer peripheral side of the superposed end portions 3a and 3b is connected at a predetermined interval in the axial direction of the screen to a portion 3c of the spiral wedge-wire screen 3 other than the superposed end portions 3a and 3b by means of connecting wires 6 which pass through a hollow central portion 2b of the perforated base pipe 2.

More specifically, end portions of the spiral wedge-wire 5 of the spiral wedge-wire screen 3 corresponding to the end portions 3a and 3b are formed at a predetermined interval with insertion holes 5f and 5g (FIG. 2) for inserting the connecting wires 6 therethrough and a portion of the spiral wedge-wire 5 which is diametrically opposite to the holes 5f and 5g is formed with insertion holes 5h (FIG. 2) for inserting the connecting wires 6 therethrough. Each of the connecting wires 6 is made, for example, by twining a plurality of steel lines together. By passing the connecting wires 6 from the insertion holes 5f through the insertion holes 5g and the liquid collection holes 2a of the perforated base pipe 2 to the insertion holes 5h and

forming knots 6a at both ends of the connecting wires 6, the end portion 3a on the outer peripheral side of the spiral wedge-wire screen 3 is connected to the portion 3c of the spiral wedge-wire screen 3 other than the end portions 3a and 3b. In the example shown in FIGs. 1 and 2, the portion 3c other than the end portions is a portion which is diametrically opposed to the end portions 3a and 3b and the connecting wires 6 extend in the diametrical direction through the hollow central portion 2b of the perforated base pipe 2 from the end portion 3a to the portion 3c. The portion other than the end portions 3a and 3b to which the connecting wires 6 are connected is not limited to the portion diametrically opposed to the end portions 3a and 3b but it may be a portion which is deviated from the portion diametrically opposed to the end portions 3a and 3b, such as a portion 3d shown in FIG. 9, so long as it is in a location where a connecting wire cutting pipe or rod to be described later can abut against the connecting wires 6 when the cutting pipe or rod is inserted in the perorated base pipe 2.

For installing this expandable screen 1, as shown in FIG. 5, the screen 1 is placed in a well bore 7 of a horizontal or high-angle well and then, as shown in FIG. 6, a connecting wire cutting pipe or rod 8 having an outer diameter which is smaller than the inner diameter of the perforated base pipe 2 and is sufficient for abutting against the connecting wires 6 passing through the hollow central portion 2b of the perforated base pipe 2 when the connecting wire cutting pipe or rod 8 is inserted in the perforated base pipe 2 is inserted in the perforated base pipe 2 and the connecting wires 6 extending in the perforated base pipe 2 at a predetermined interval in the axial direction of the screen are cut one by one by the connecting wire cutting pipe or rod 8. The elastically deformed spiral wedge-wire screen 3 of the screen 1 thereby expands and assumes the form shown in FIG. 7. By this expansion of the sprial wedge-wire screen 3, the spiral wedge-wire screen 3 is disposed

in a manner to cover an inner wall 7 of the well bore 7 as shown in FIG. 8, and thereby prevents movement of sand grains accompanying flowing in of crude oil. In the expanded screen 1, a gap 3g is produced between the end portions 3a and 3b of the spiral wedge-wire screen 3 and the screen 1 may be designed in such a manner that this gap 3g becomes smaller than the diameter of sand which should be prevented from flowing into the screen 1.

FIGs. 10 and 11 show another embodiment of the invention in which FIG. 10 is a perspective view thereof and FIG. 11 is a cross section showing the expandable screen installed in a well in an expanded state. In this and subsequent embodiments, the same or similar components as those of the embodiment of FIGs. 1 to 9 are designated by the same reference characters and description thereof will be omitted.

In an expandable screen 10 shown in FIG. 10, a wire mesh 11extending in the axial direction of the screen is provided between end portions 3a and 3b in the circumferential direction of a spiral wedge-wire screen 3 and end portions 11a and 11b of the wire mesh 11 in the circumferential direction (FIG. 11) are welded to the end portions 3a and 3b of the spiral wedge-wire screen 3. As shown in FIG. 11, when the spiral wedge-wire screen 3 has expanded, a gap 3g produced between the end portions 3a and 3b thereof is closed by the wire mesh 11 whereby invasion of sand into the screen through the gap 3g can be prevented. Therefore, movement of sand can be more effectively prevented.

FIGs. 12, 13A and 13B show another embodiment of the invention in which FIG. 12 is a perspective view and FIG. 13A is a cross section showing an expandable screen installed in a well bore and FIG. 13B is a cross section showing the expandable screen in an expanded state.

In this embodiment, an expandable screen 20 comprises a perforated base pipe 2 formed with a multitude of liquid collection holes 2a and an inner spiral wedge-wire screen 23 comprising a plurality of support rods 24 extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire 25 wound about the support rods 24 on the outer peripheral side of the support rods 24 to form a slit 25a of a predetermined width and being welded to the support rods 24. The expandable screen 20 further comprises an outer spiral wedge-wire screen 3 comprising a plurality of support rods 4 extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire 5 wound about the support rods 4 on the outer peripheral side of the support rods 4 to form a slit 5a of a predetermined width and being welded to the support rods 4. The spiral wedge-wire 5 is cut in the axial direction of the screen at a point C in the circumferential direction. The outer spiral wedge-wire screen 3 has an outer diameter which is almost equal to or slightly smaller than a diameter of a well-bore in which the screen is installed and an inner diameter which is larger than an outer diameter of the inner spiral wedge-wire screen 23 by a predetermined value.

The outer spiral wedge-wire screen 3 is wrapped on the outer periphery of the inner sprial wedge-wire screen 23 with end portions 3a and 3b of the outer spiral wedge-wire screen 3 in the circumferential direction being superposed one upon the other and thereby urging the outer spiral wedge-wire screen 3 to expand, and the end portion 3a on the outer peripheral side of the outer superposed end portions 3a and 3b is connected at a predetermined interval in the axial direction of the screen to a portion 3c of the outer spiral wedge-wire screen 3 other than the superposed end portions 3a and 3b by means of connecting wires 6 which pass through a hollow central portion 2b of the perforated base pipe 2 and connecting wire insertion

holes 25b and 25c formed in the inner spiral wedge-wire 25.

According to this embodiment, as shown in FIG. 13B, when the outer spiral wedge-wire screen 3 has expanded in a well bore 7, sand grains may flow in through a gap 3g produced between the end portions 3a and 3b of the outer spiral wedge-wire screen 3 but flowing of sand grains into the screen is interrupted by the inner spiral wedge-wire screen 23.

FIGs. 14 and 15 show another embodiment of the invention in which FIG. 14 is a perspective view of an expandable screen of the embodiment and FIG. 15 is a cross section showing the expandable screen installed in a well bore in an expanded state.

This embodiment is a modification of the expandable screen shown in FIG. 12 having an outer spiral wedge-wire screen. An expandable screen 30 has a mesh filter 32 made of wire-mesh covering the entire outer peripheral surface of the outer spiral wedge-wire screen 3. As will be apparent from FIG. 15, end portions 32a an 32b in the circumferential direction of the mesh filter 32 are welded to the end portions 3a and 3b of the outer spiral wedge-wire screen 3.

By this arrangement, when the outer spiral wedge-wire screen 3 has expanded, the mesh filter 32 expands to a small gap between an inner wall 7a of the well bore 7 and the outer spiral wedge-wire screen 3 whereby movement of sand can be more effectively prevented.

FIGs. 16 and 17 show another embodiment of the invention in which FIG. 16 is a perspective view of an expandable screen of the embodiment and FIG. 17 is a cross section showing the expandable screen installed in a well

bore in an expanded state.

This embodiment is a modification of the expandable screen of FIG. 12 having an outer spiral wedge-wire screen An extendable screen 40 further has a plurality of skid rods 42 made of metal rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen. The skid rods 42 are welded to the outer periphery of the outer spiral wedge-wire screen 3.

In the illustrated example, the skid rods 42 are made of linear steel wires having a wedge-shaped cross section. The skid rods 42 are arranged as in the outer spiral wedge-wire 5, in such a manner that their flat surfaces 42b face outside and the other two sides 42c and 42d define space with the adjacent skid rods which widens gradually radially inwardly, i.e., toward the inside of the screen. The skid rods 42 are welded at their inside apexes 42e to the flat surface 5b of the outer periphery of the outer spiral wedge-wire 5. The interval of the adjacent skid rods 42 is so set that the interval at the same plane as the outside flat surface 42b will become larger than the width of the outside flat surface 42b.

The shape of the skid rods 42 is not limited to the illustrated one but other shape such as a circular cross section and a polygonal cross section may be used. In any case, the interval between the adjacent skid rods 42 is so set that it will become larger than the diameter of the skid rods 42.

According to this arrangement, the skid rods 42 perform the function of a sleigh in inserting the screen into the well bore and thereby mitigates friction between the outer periphery of the screen and the wall of the well. As a result, the screen can be inserted in the well bore easily and smoothly

and time required for inserting the screen in the well bore can be shortened. Additionally, the skid rods 42 protect the outer spiral wedge-wire screen provided on the outermost periphery of the screen from the outside and, therefore, the outer spiral wedge-wire screen does not come into direct contact with the wall of the well whereby damage to the outer spiral wedge-wire screen due to friction with the wall of the well can be prevented.

FIGs. 18A, 18B and 19 show another embodiment of the invention in which FIG. 18A is a perspective view of an expandable screen, FIG. 18B is a cross section of the expandable screen and FIG. 19 is a cross section showing the expandable screen installed in a well bore in an expanded state. For convenience of illustration, the mesh filter is shown partially in FIG. 18A.

In this embodiment, an expandable screen 50 comprises a perforated base pipe 2 formed with a multitude of liquid collection holes 2a and a plurality of steel plates 52 in the form of a belt rounded annularly and wrapped on the outer periphery of the base pipe 2 at a predetermined interval in the axial direction of the screen with end portions 52a and 52b of each of the steel plates 52 being superposed one upon the other thereby urging the steel plate 52 to expand. The end portion 52a on the outer peripheral side of the superposed end portions 52a and 52b is connected to a portion 52c of the steel plate 52 other than the superposed end portions 52a and 52b by means of connecting wires 6 which pass through a hollow central portion 2b of the perforated base pipe 2. A mesh filter 53 covers the outer periphery of a portion of the perforated base pipe 2 between the rounded steel plates 52 provided at both ends in the axial direction of the screen and the outer periphery of the respective steel plates 52. End portions in the circumferential direction of the screen of the mesh filter 53 are welded to the end portions 52a and 52b in the circumferential direction of the screen of the

steel plates 52.

In installing this expandable screen 50, the screen 50 is installed in a well bore 7 of a horizontal or high-angle well and then a connecting wire cutting pipe (or rod) (not shown) having an outer diameter which is smaller than the inner diameter of the perforated base pipe 2 and is sufficient for abutting against the connecting wires 6 passing through the hollow central portion 2b of the perforated base pipe 2 when the connecting wire cutting pipe or rod is inserted in the perforated base pipe 2 is inserted in the perforated base pipe 2 and the connecting wires 6 are cut one by one.

The elastically deformed steel plates 52 of the screen 50 thereby expand to assume the state shown in FIG. 19 and the mesh filter 53 covers the inner wall 7a thereby preventing movement of sand. In this case, a gap 52g is produced between the end portions 52a and 52b of the expanded steel plates 52 and the screen 50 is designed so that the gap 52g will become sufficiently smaller than the diameter of sand grain which should be prevented from flowing into the screen.

FIGs. 20 and 21 show a modification of the embodiment of FIG. 1. These figures are cross sections showing an expandable wedge-wire screen in an expanded state. In FIGs. 20 and 21, illustration of the perforated base pipe is omitted for convenience of illustration.

In this embodiment, a support rod 60 has a wedge-shaped cross section as will be apparent from FIG. 22 showing it in a partially enlarged scale with two sides 60a thereof being formed in flat surfaces. Length L1 of the support rod 60 in the radial direction of the screen is designed to be larger than length L2 of the wedge wire screen 3 in the radial direction of the

screen.

When, after expansion of the wedge-wire screen 3 and completion of installation of the screen, pressure has been applied in a direction of reducing the diameter of the wedge-wire screen 3 by crude oil and sand grains which tend to flow into the screen, there occurs a case where the end portions 3a and 3b in the circumferential direction of the wedge-wire screen 3 slide relative to each other in an offset state. FIG. 20 shows a case where the end portions 3a and 3b slide in directions X and X' with the end portion 3b sliding inside of the end portion 3a. FIG. 21 shows a case where the end portions 3a and 3b slide in directions X and X' with the end portion 3a sliding inside of the end portion 3b.

In the case of FIG. 20, the edge of the end portion 3b abuts against the endmost support rod 60 provided in the other end portion 3a and the support rod 60 thereby performs a function as a stopper, preventing further relative sliding movement of the end portions 3a and 3b in the directions X and X'. Likewise, in the case of FIG. 21, the edge of the end portion 3a abuts against the endmost support rod 60 provided in the other end portion 3b thereby preventing further relative sliding movement of the end portions 3a and 3b. By this arrangement, damage to the screen due to an excessive relative sliding movement of the end portions 3a and 3b can be prevented. Since the support rod 60 has a wedge-shaped cross section and the side surface of the support rod 60 to which the end portion 3a or 3b abuts is a flat surface and therefore is not so slippery as a support rod of a circular cross section, the support rod 60 can support the edge of the end portion 3a or 3b more securely than the support rod of a circular cross section.

For the purpose of this embodiment, the cross section of the support rod

is not limited to the wedge-shape but, as shown in FIG. 23 for example, a support rod 70 may have a pentagonal cross section or other cross section which has a flat side surface extending in the radial direction of the screen.

FIG. 24 shows another embodiment which is a modification of the screen having skid rods shown in FIG. 16. FIG. 24 is a cross section showing an expandable wedge-wire screen in an expanded state. In FIG. 24, illustration of the perforated base pipe and the inner spiral wedge-wire screen is omitted for convenience of illustration.

In this embodiment, a support rod 60 has a wedge-shaped cross section. When an end portion 3a of the wedge-wire screen 3 enters inside of an end portion 3b due to pressure of crude oil and sand which tend to flow into the screen and the end portions 3a and 3b slide in directions X and X', an endmost support rod 60 disposed in the end portion 3b abuts against an endmost skid rod 42 disposed in the end portion 3a whereby the skid rod 42 functions as a stopper and prevents further relative sliding movement of the end portions 3a and 3b in the directions X and X'.

FIGs. 25 and 26 show another embodiment which is a modification of the embodiment of FIG. 1. These figures show an expandable wedge-wire screen in an expanded state. Illustration of the perforated base pipe is omitted for convenience of illustration.

In this embodiment, a support rod 60 has a wedge-shaped cross section. This embodiment is different from the embodiment of FIG. 1 in that a filter mesh 80 is provided inside of the support rods 60 and is welded to the support rods 60 for enhancing the filter function after expansion of the screen. The function of the support rod 60 as a stopper in the case where end portions 3a

and 3b of a wedge-wire screen 3 slide in an offset state in directions X and X' due to pressure applied by crude oil and sand is the same as that of the embodiment shown in FIGs. 20 and 21 and, therefore, detailed description thereof will be omitted.

FIG. 27 shows another embodiment which is a modification of the embodiment of FIG. 16 having skid rods. This figure is a cross section showing an expandable wedge-wire screen in an expanded state. Illustration of the perforated base pipe and inner spiral wedge-wire screen is omitted for convenience of illustration.

In this embodiment, a support rod 60 has a wedge-shaped cross section. This embodiment is different from the embodiment of FIG. 16 in that a filter mesh 80 is provided inside of the support rods 60 and is welded to the support rods 60 for enhancing the filter function after expansion of the screen. The function of the support rod 60 as a stopper in the case where end portions 3a and 3b of a wedge-wire screen 3 slide in an offset state in directions X and X' due to pressure applied by crude oil and sand is the same as that of the embodiment shown in FIGs. 20 and 21 and, therefore, detailed description thereof will be omitted.

FIGs. 28 and 29 show another embodiment which is a modification of the embodiment of FIG. 14 having a mesh filter. These figures are cross sections showing an expandable wedge-wire screen in an expanded state. Illustration of the perforated base pipe and inner spiral wedge-wire screen is omitted for convenience of illustration.

This embodiment is different from the embodiment of FIG. 14 in that the support rod 60 has a wedge-shaped cross section. The function of the

support rod 60 as a stopper in the case where end portions 3a and 3b of a wedge-wire screen 3 slide in an offset state in directions X and X' due to pressure applied by crude oil and sand is the same as that of the embodiment shown in FIGs. 20 and 21 and, therefore, detailed description thereof will be omitted.

FIGs. 30 and 31 show another embodiment which is a modification of the embodiment of FIG. 1. FIG. 30 is a vertical section showing an expandable wedge-wire screen in an expanded state and FIG. 31 is a cross section thereof. In these figures, the same component parts as those of FIG. 1 are designated by the same reference characters and description thereof will be omitted.

In this embodiment, a plurality of perforated base pipes 2 are connected in series by a joint 82 and a spiral wedge-wire screen 3 provided on the outer peripheral side of the perforated base pipes 2 consists of a plurality of screen portions 3-1, 3-2 etc. disposed at a predetermined interval in the axial direction of the screen. A mesh filter 80 is provided over the outer peripheral surface of the screen portions, a gap 3g (FIG. 31) between the end portions in the circumferential direction of the respective screen portions 3-1, 3-2 etc. and the interval 83 between adjacent ones of the screen portions 3-1, 3-2 etc. End portions of the mesh filter 80 in the axial direction of the screen are fixed by rings 80a to the outer periphery of the perforated base pipe 2 in the vicinity of the joint 82.

By this arrangement, since the spiral wedge-wire screen 3 is divided in the axial direction into a plurality of screen portions 3-1, 3-2 etc. with the predetermined interval 83, the screen can pass easily through a curved portion of the horizontal well and, further, when the wedge-wire screen 3 has

expanded, the mesh filter 80 expands even to a small gap between the wall 7a and the wedge-wire screen 3 thereby preventing movement of sand more completely. Since, further, the interval 83 between the screen portions 3-1, 3-2 etc. is covered by the mesh filter 80, invasion of sand from this interval 83 can also be prevented.

Industrial Utility

The expandable screen according to the invention is useful for preventing invasion of sand accompanying flow of liquid such as crude oil into the screen in a horizontal or high-angle well.

Claims:

1. An expandable screen for a horizontal or high-angle well comprising:

a perforated base pipe formed with a multitude of liquid collection holes;

a spiral wedge-wire screen comprising a plurality of support rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire wound about the support rods on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods, said spiral wedge-wire being cut in the axial direction of the screen at a point in the circumferential direction, and said spiral wedge-wire screen having an outer diameter which is almost equal to or slightly smaller than a diameter of a well-bore in which the screen is installed and an inner diameter which is larger than an outer diameter of the perforated base pipe by a predetermined value;

said spiral wedge-wire screen being wrapped on the outer periphery of the perforated base pipe with end portions of the spiral wedge-wire screen in the circumferential direction being superposed one upon the other and thereby urging the spiral wedge-wire screen to expand, and the end portion on the outer peripheral side of the superposed end portions being connected at a predetermined interval in the axial direction of the screen to a portion of the spiral wedge-wire screen other than the superposed end portions by means of connecting wires which pass through a hollow central portion of the perforated base pipe.

2. An expandable screen as defined in claim 1 wherein a wire-mesh is provided between the end portions in the circumferential direction of the spiral wedge-wire screen and end portions in the circumferential direction of the wire-mesh are welded to the end portions in the circumferential direction

of the spiral wedge-wire screen.

3. An expandable screen as defined in claim 1 wherein the spiral wedge-wire screen consists of a plurality of screen portions disposed at a predetermined interval in the axial direction of the screen and a mesh filter is provided over the outer peripheral surface of the screen portions, a gap between the end portions in the circumferential direction of the respective screen portions and the interval between adjacent ones of the screen portions.

4. An expandable screen for a horizontal or high-angle well comprising:

a perforated base pipe formed with a multitude of liquid collection holes;

an inner spiral wedge-wire screen comprising a plurality of support rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire wound about the support rods on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods;

an outer spiral wedge-wire screen comprising a plurality of support rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire wound about the support rods on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods, said spiral wedge-wire being cut in the axial direction of the screen at a point in the circumferential direction, and said spiral wedge-wire screen having an outer diameter which is almost equal to or slightly smaller than a diameter of a well-bore in which the screen is installed and an inner diameter which is larger than an outer diameter of the inner spiral wedge-wire screen by a predetermined value;

said outer spiral wedge-wire screen being wrapped on the outer periphery of the inner sprial wedge-wire screen with end portions of the outer

spiral wedge-wire screen in the circumferential direction being superposed one upon the other and thereby urging the outer spiral wedge-wire screen to expand, and the end portion on the outer peripheral side of the outer superposed end portions being connected at a predetermined interval in the axial direction of the screen to a portion of the outer spiral wedge-wire screen other than the superposed end portions by means of connecting wires which pass through a hollow central portion of the perforated base pipe.

5. An expandable screen as defined in claim 4 wherein a mesh filter is provided on the outer periphery of the outer spiral wedge-wire screen and end portions in the circumferential direction of the mesh filter are welded to the end portions in the circumferential direction of the outer spiral wedge-wire screen.

6. An expandable screen as defined in claim 4 further comprising a plurality of skid rods made of metal rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen, said skid rods being welded to the outer periphery of the outer spiral wedge-wire screen.

7. An expandable screen as defined in any of claims 1 – 6 wherein said support rods have either a wedge-shape or a polygonal shape.

8. An expandable screen as defined in claim 7 wherein said support rods have a length in the radial direction of the screen which is larger than a length in the radial direction of the screen of the outer spiral wedge-wire screen.

9. An expandable screen for a horizontal or high-angle well comprising:

a perforated base pipe formed with a multitude of liquid collection holes;

a plurality of steel plates in the form of a belt rounded annularly and wrapped on the outer periphery of the base pipe at a predetermined interval in the axial direction of the screen with end portions of each of the steel plates being superposed one upon the other thereby urging the steel plate to expand, and the end portion on the outer peripheral side of the superposed end portions being connected to a portion of the steel plate other than the superposed end portions by means of connecting wires which pass through a hollow central portion of the perforated base pipe; and

a mesh filter covering the outer periphery of a portion of the perforated base pipe between the rounded steel plates provided at both ends in the axial direction of the screen and the outer periphery of the respective steel plates, end portions in the circumferential direction of the screen of the mesh filter being welded to the end portions in the circumferential direction of the screen of the steel plates.

10. A method for installing an expandable screen for a horizontal or high-angle well comprising:

(1) a step of installing an expandable screen in a predetermined location in a well bore, said screen comprising:

a perforated base pipe formed with a multitude of liquid collection holes;

a spiral wedge-wire screen comprising a plurality of support rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire wound about the support rods on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods, said spiral wedge-wire being cut in the axial direction of the screen at a point in the circumferential direction, and said spiral wedge-wire screen having an outer diameter which is almost equal to or slightly smaller than a diameter of a well-bore in which the screen is installed and an inner diameter which is

larger than an outer diameter of the perforated base pipe by a predetermined value;

said spiral wedge-wire screen being wrapped on the outer periphery of the perforated base pipe with end portions of the spiral wedge-wire screen in the circumferential direction being superposed one upon the other and thereby urging the spiral wedge-wire screen to expand, and the end portion on the outer peripheral side of the superposed end portions being connected at a predetermined interval in the axial direction of the screen to a portion of the spiral wedge-wire screen other than the superposed end portions by means of connecting wires which pass through a hollow central portion of the perforated base pipe.

(2) a step of inserting into the perforated base pipe a connecting wire cutting pipe or rod having an outer diameter which is smaller than the inner diameter of the perforated base pipe and is sufficient for abutting against the connecting wires passing through the hollow central portion of the perforated base pipe when the connection wire cutting pipe or rod is inserted in the perforated base pipe and cutting the connecting wires one by one to expand the spiral wedge-wire screen.

11. A method as defined in claim 10 wherein the expandable screen further comprises a wire-mesh provided between the end portions in the circumferential direction of the spiral wedge-wire screen and end portions in the circumferential direction of the wire-mesh are welded to the end portions in the circumferential direction of the spiral wedge-wire screen.

12. A method as defined in claim 10 wherein the expandable screen is one wherein the spiral wedge-wire screen consists of a plurality of screen portions disposed at a predetermined interval in the axial direction of the screen and a mesh filter is provided over the outer peripheral surface of the screen

portions, a gap between the end portions in the circumferential direction of the respective screen portions and the interval between adjacent ones of the screen portions.

13. A method for installing an expandable screen for a horizontal or high-angle well comprising:

(1) a step of installing an expandable screen in a predetermined location in a well bore, said screen comprising:

a perforated base pipe formed with a multitude of liquid collection holes;

an inner spiral wedge-wire screen comprising a plurality of support rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire wound about the support rods on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods;

an outer spiral wedge-wire screen comprising a plurality of support rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen and a spiral wedge wire wound about the support rods on the outer peripheral side of the support rods to form a slit of a predetermined width and being welded to the support rods, said spiral wedge-wire being cut in the axial direction of the screen at a point in the circumferential direction, and said spiral wedge-wire screen having an outer diameter which is almost equal to or slightly smaller than a diameter of a well-bore in which the screen is installed and an inner diameter which is larger than an outer diameter of the inner spiral wedge-wire screen by a predetermined value;

said outer spiral wedge-wire screen being wrapped on the outer periphery of the inner sprial wedge-wire screen with end portions of the outer spiral wedge-wire screen in the circumferential direction being superposed one upon the other and thereby urging the outer spiral wedge-wire screen to

expand, and the end portion on the outer peripheral side of the outer superposed end portions being connected at a predetermined interval in the axial direction of the screen to a portion of the outer spiral wedge-wire screen other than the superposed end portions by means of connecting wires which pass through a hollow central portion of the perforated base pipe.

(2) a step of inserting into the perforated base pipe a connecting wire cutting pipe or rod having an outer diameter which is smaller than the inner diameter of the perforated base pipe and is sufficient for abutting against the connecting wires passing through the hollow central portion of the perforated base pipe when the connecting wire cutting pipe or rod is inserted in the perforated base pipe and cutting the connecting wires one by one to expand the outer spiral wedge-wire screen.

14. A method as defined in claim 13 wherein the expandable screen further comprises a mesh filter provided on the outer periphery of the outer spiral wedge-wire screen and end portions in the circumferential direction of the mesh filter are welded to the end portions in the circumferential direction of the outer spiral wedge-wire screen.

15. A method as defined in claim 13 wherein the expandable screen further comprises a plurality of skid rods made of metal rods extending in the axial direction of the screen and disposed at a predetermined interval in the circumferential direction of the screen, said skid rods being welded to the outer periphery of the outer spiral wedge-wire screen.

16. A method as defined in any of claims 10 - 15 wherein said support rods have either a wedge-shape or a polygonal shape.

17. An expandable screen as defined in claim 16 wherein said support rods

have a length in the radial direction of the screen which is larger than a length in the radial direction of the screen of the outer spiral wedge-wire screen.

18. A method for installing an expandable screen for a horizontal or high-angle well comprising:

(1) a step of installing an expandable screen in a predetermined location in a well bore, said screen comprising:

a perforated base pipe formed with a multitude of liquid collection holes;

a plurality of steel plates in the form of a belt rounded annularly and wrapped on the outer periphery of the base pipe at a predetermined interval in the axial direction of the screen with end portions of each of the steel plates being superposed one upon the other thereby urging the steel plate to expand, and the end portion on the outer peripheral side of the superposed end portions being connected to a portion of the steel plate other than the superposed end portions by means of connecting wires which pass through a hollow central portion of the perforated base pipe; and

a mesh filter covering the outer periphery of a portion of the perforated base pipe between the rounded steel plates provided at both ends in the axial direction of the screen and the outer periphery of the respective steel plates, end portions in the circumferential direction of the screen of the mesh filter being welded to the end portions in the circumferential direction of the screen of the steel plates.

(2) a step of inserting into the perforated base pipe a connecting wire cutting pipe or rod having an outer diameter which is smaller than the inner diameter of the perforated base pipe and is sufficient for abutting against the connecting wires passing through the hollow central portion of the perforated base pipe when the connecting wire cutting pipe or rod is inserted in the perforated base pipe and cutting the connecting wires one by one to expand

the rounded steel plates.

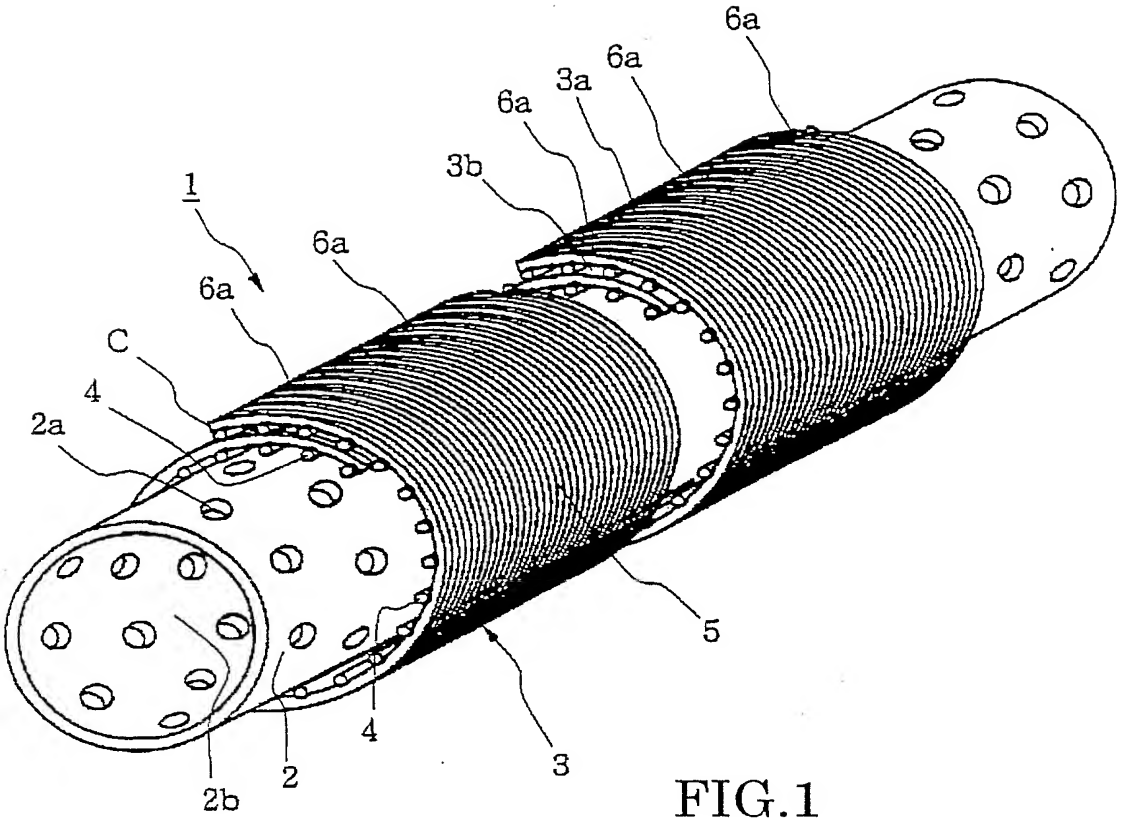

6a
6a
3a
6a
3b
1
6a
6a
C
4
2a
5
4
2
3
2b

FIG.1

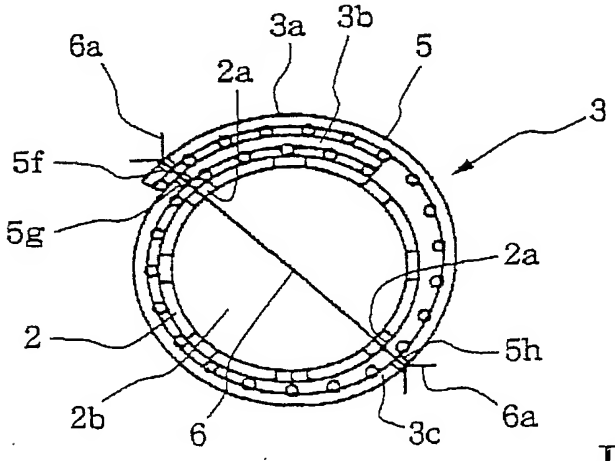

6a
3a
3b
2a
5
3
5f
5g
2a
2
5h
2b
6
3c
6a

FIG.2

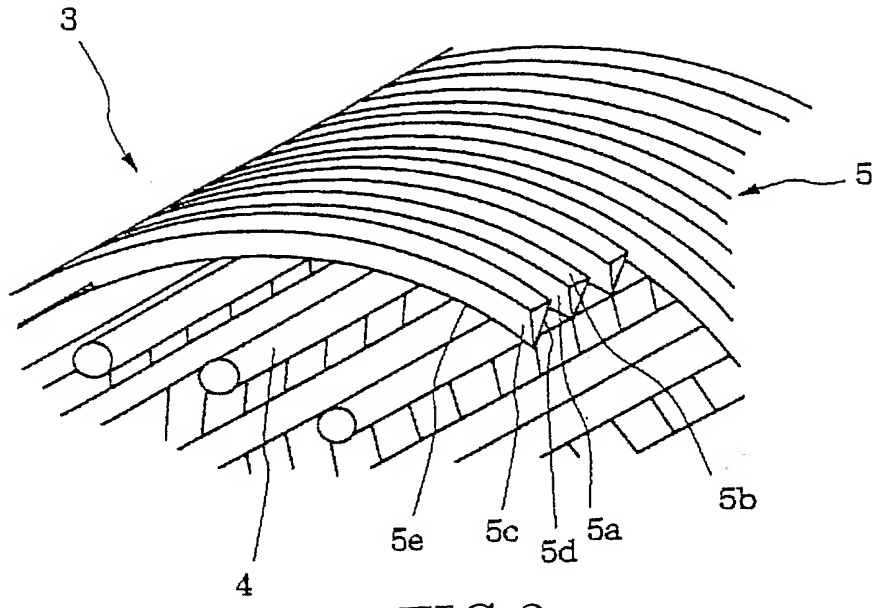


FIG.3

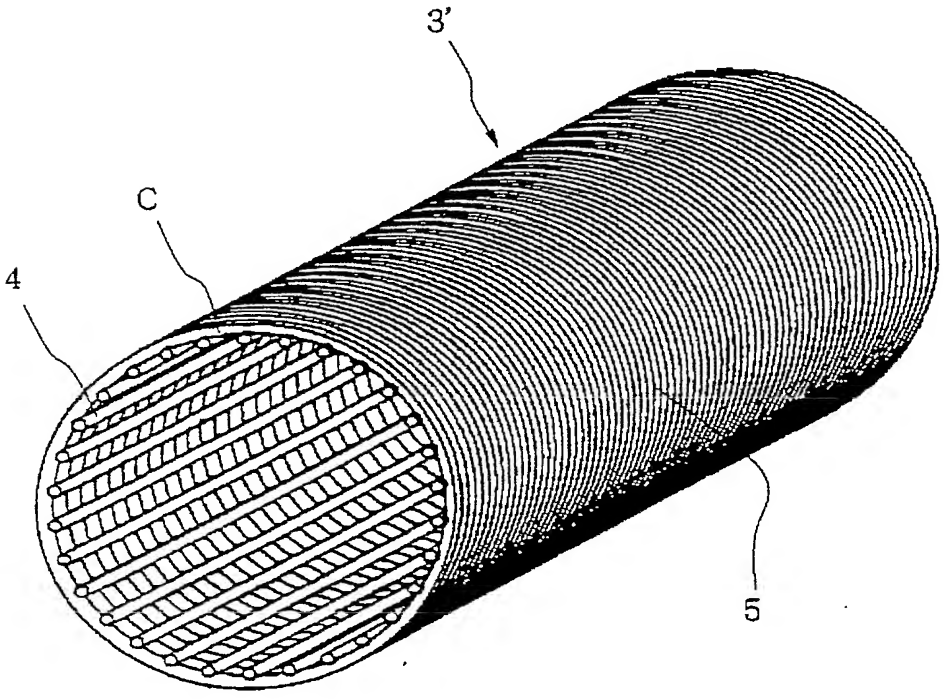


FIG.4

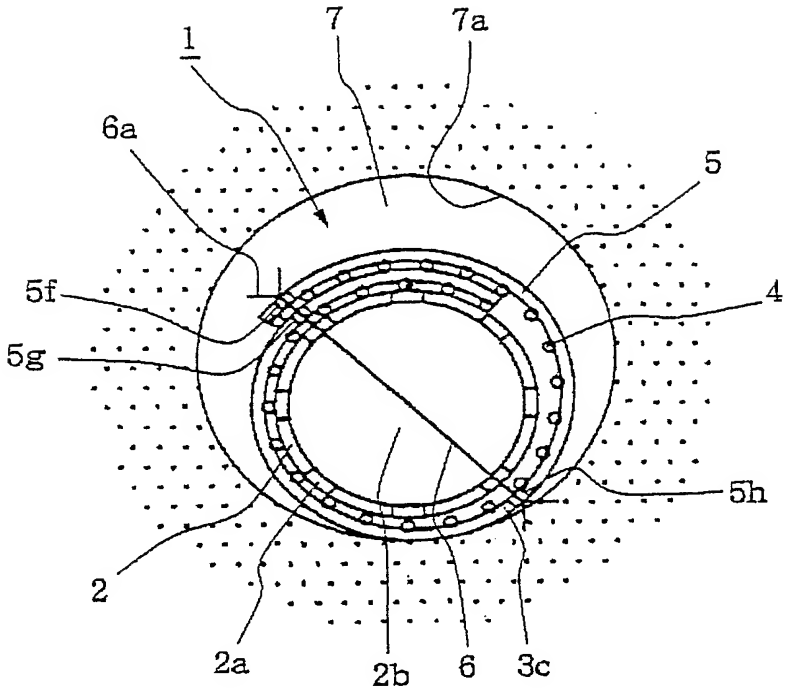


FIG.5

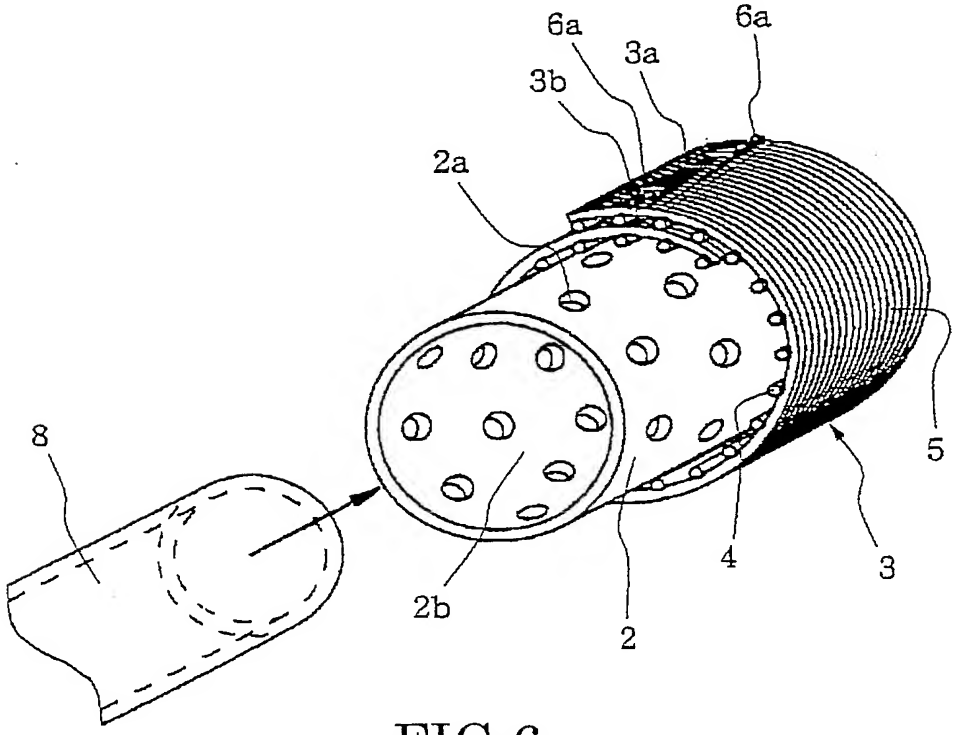


FIG.6

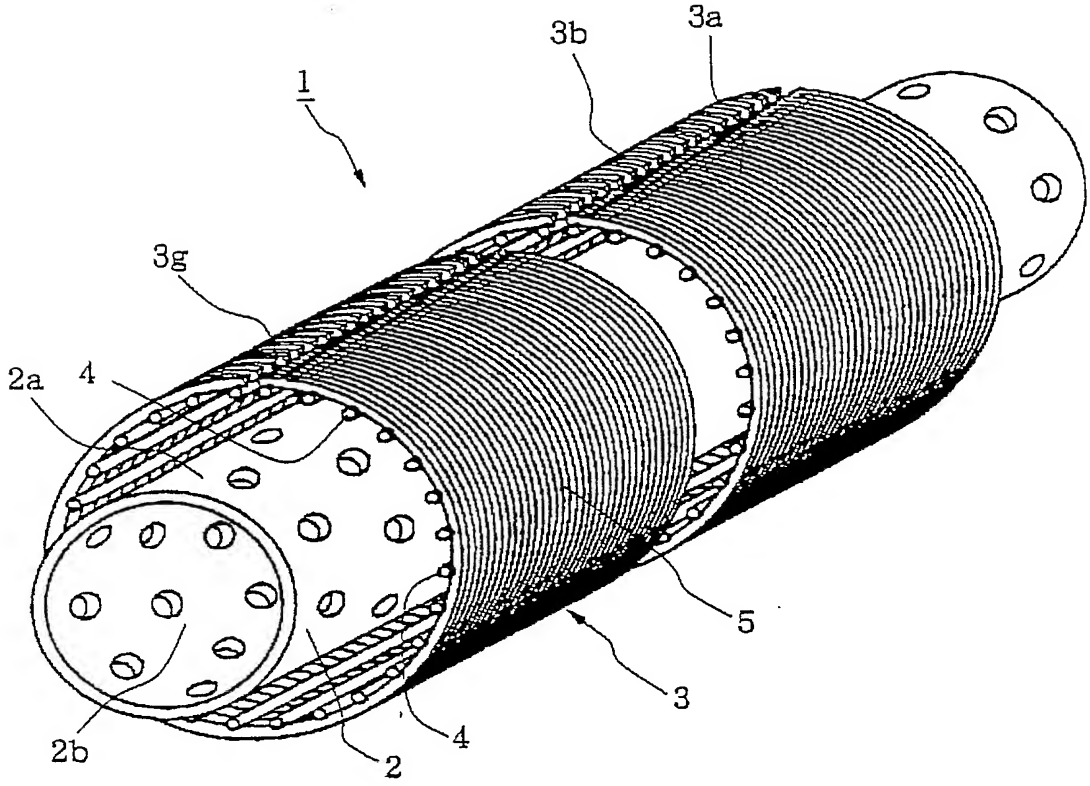


FIG.7

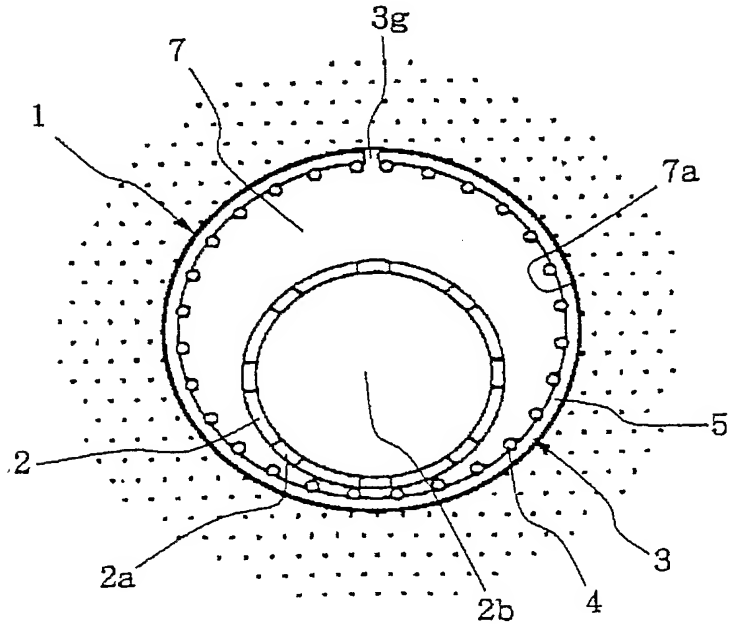


FIG.8

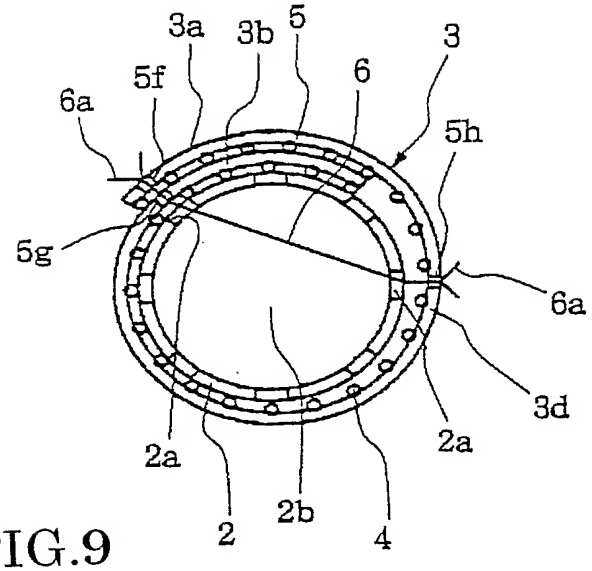
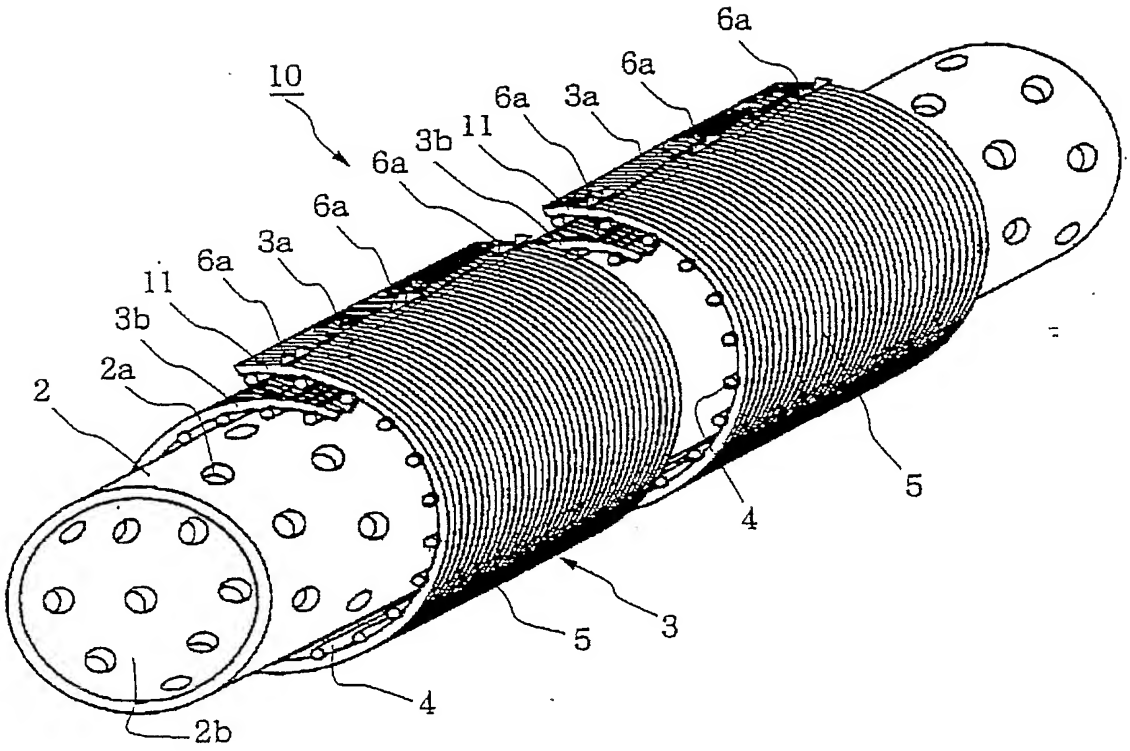

3a
3b
5
3
5f
6
6a
5h
5g
6a
3d
2a
2a
2
2b
4

FIG.9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11
6a
3b
2a
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5
4
3
5
4
2b

FIG.10

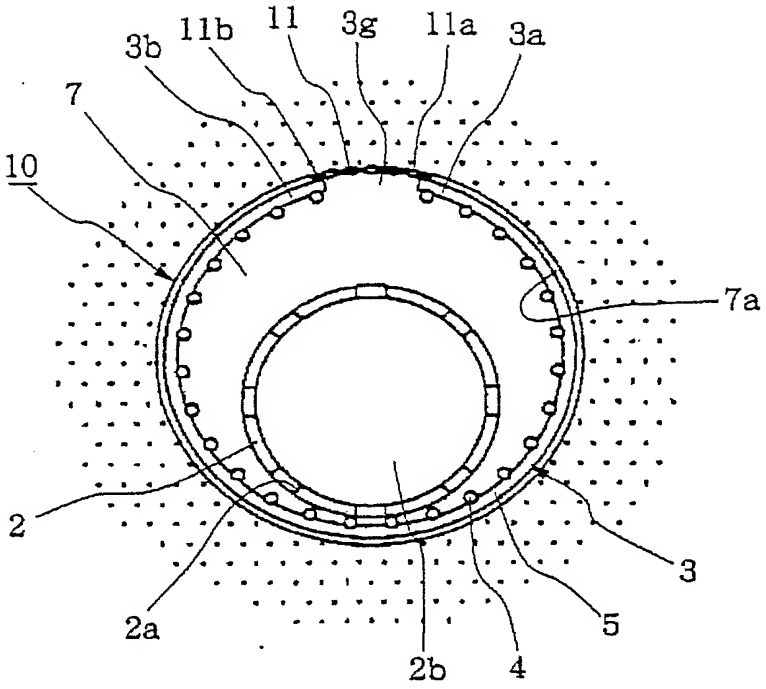


FIG.11

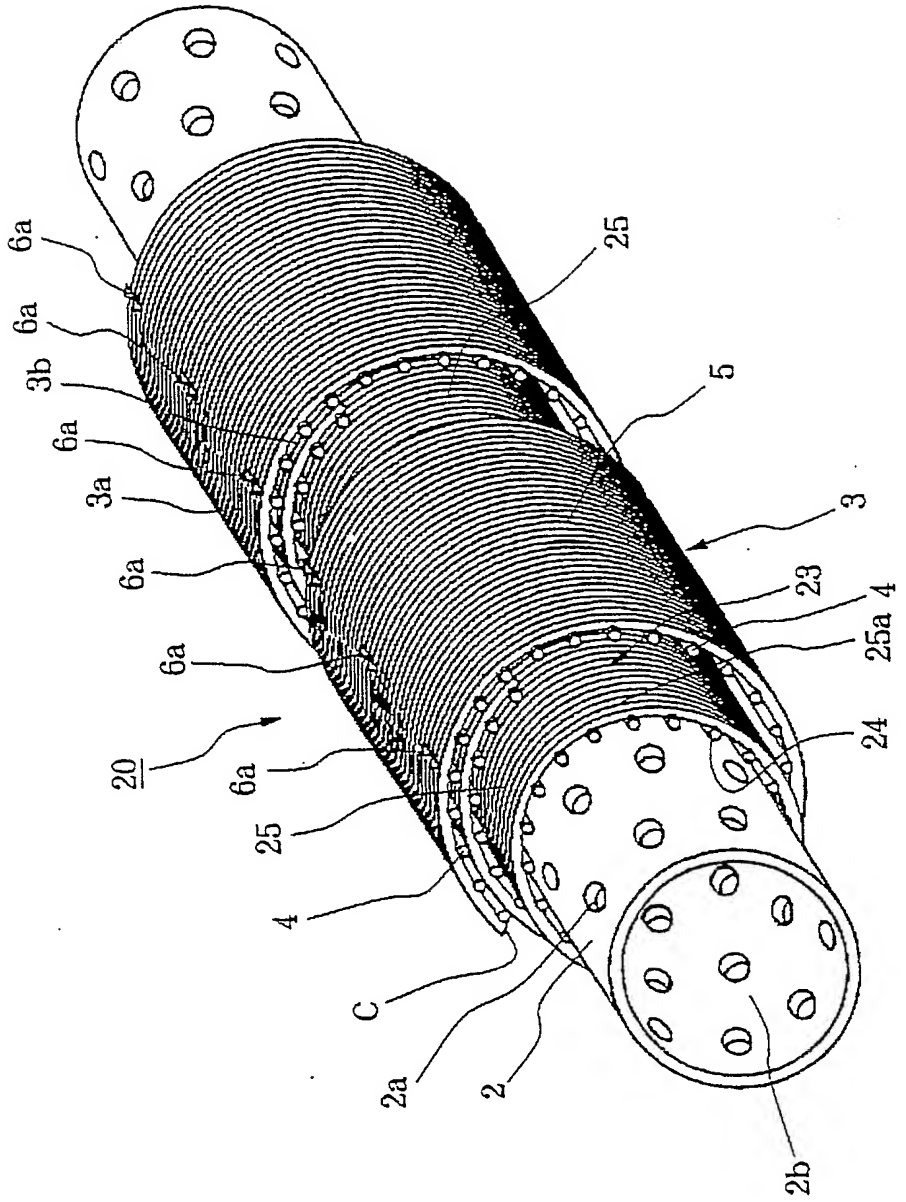


FIG.12

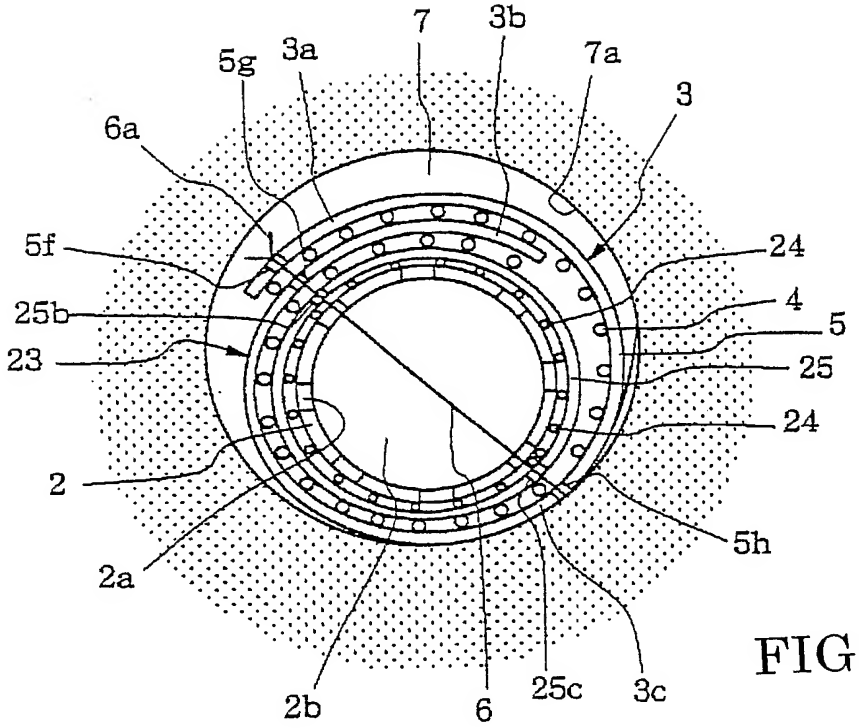


FIG.13A

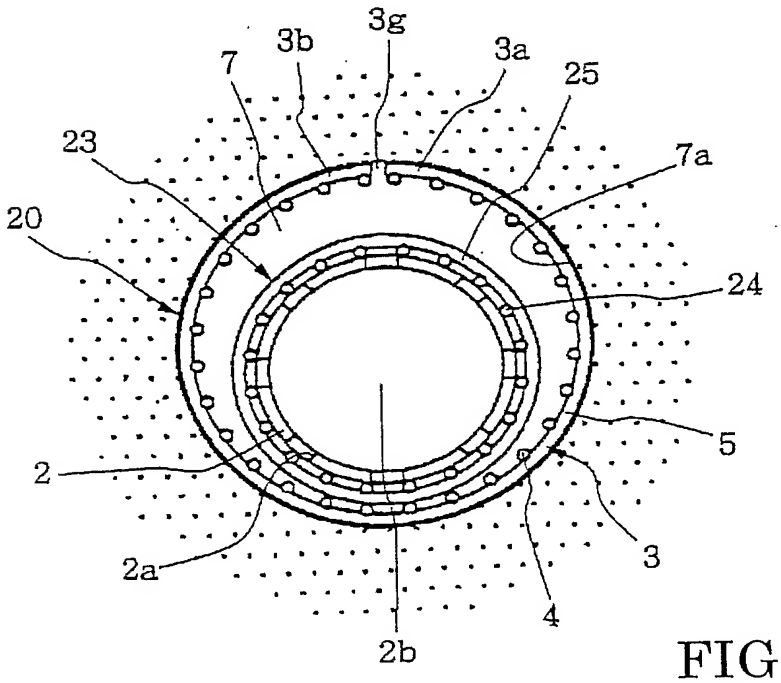


FIG.13B

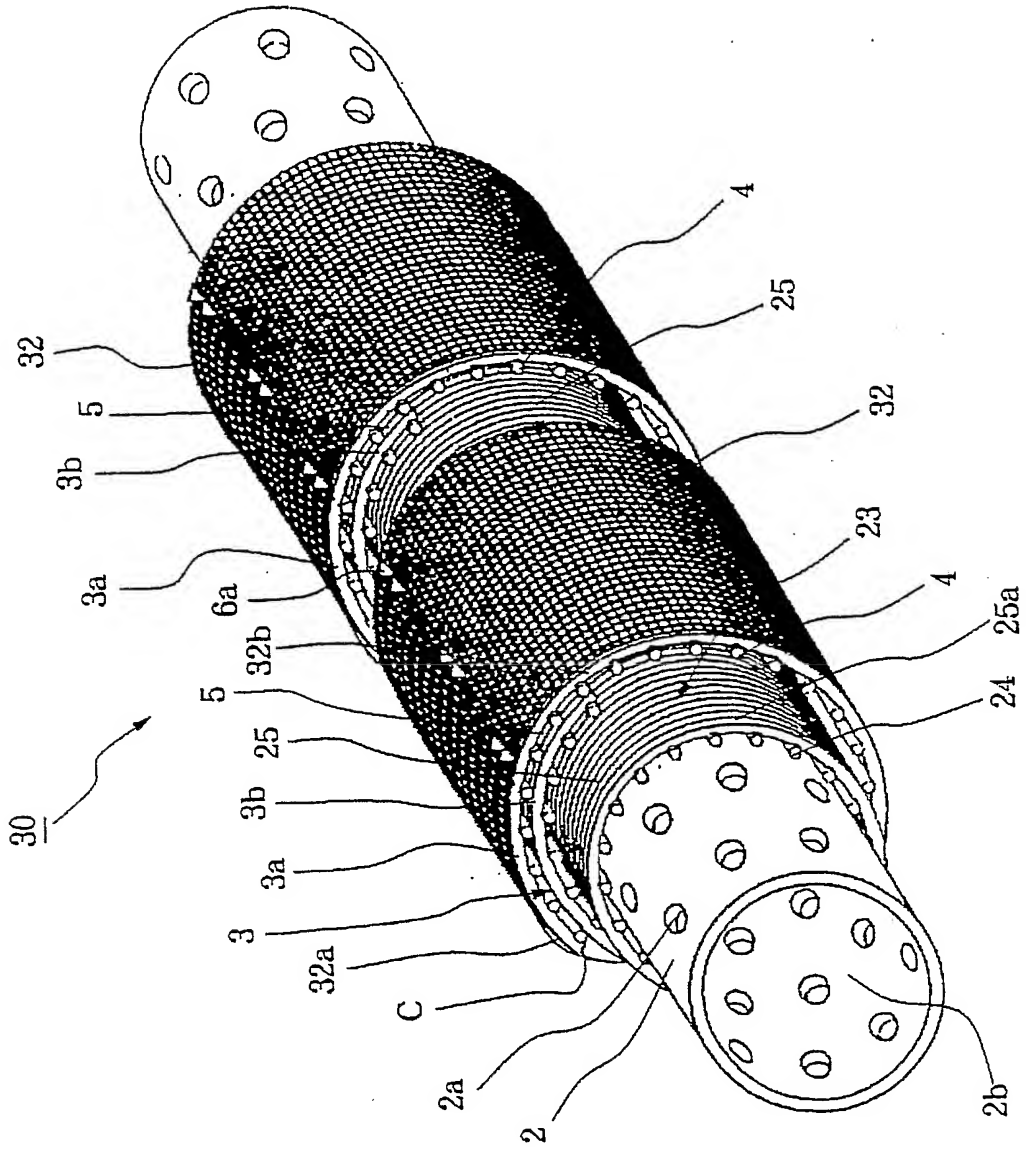


FIG.14

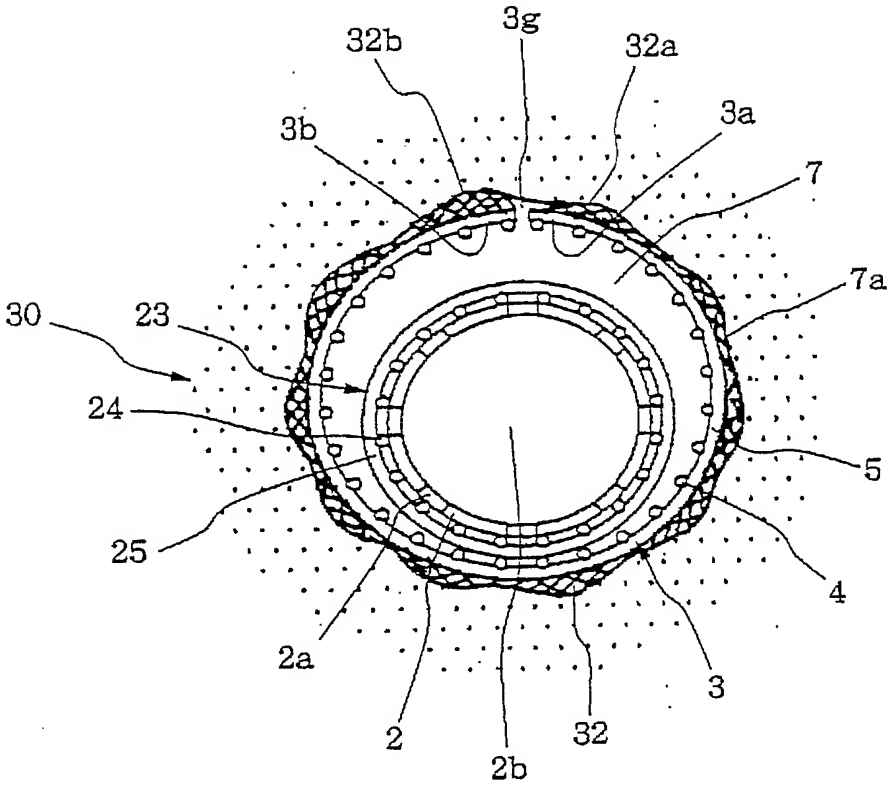
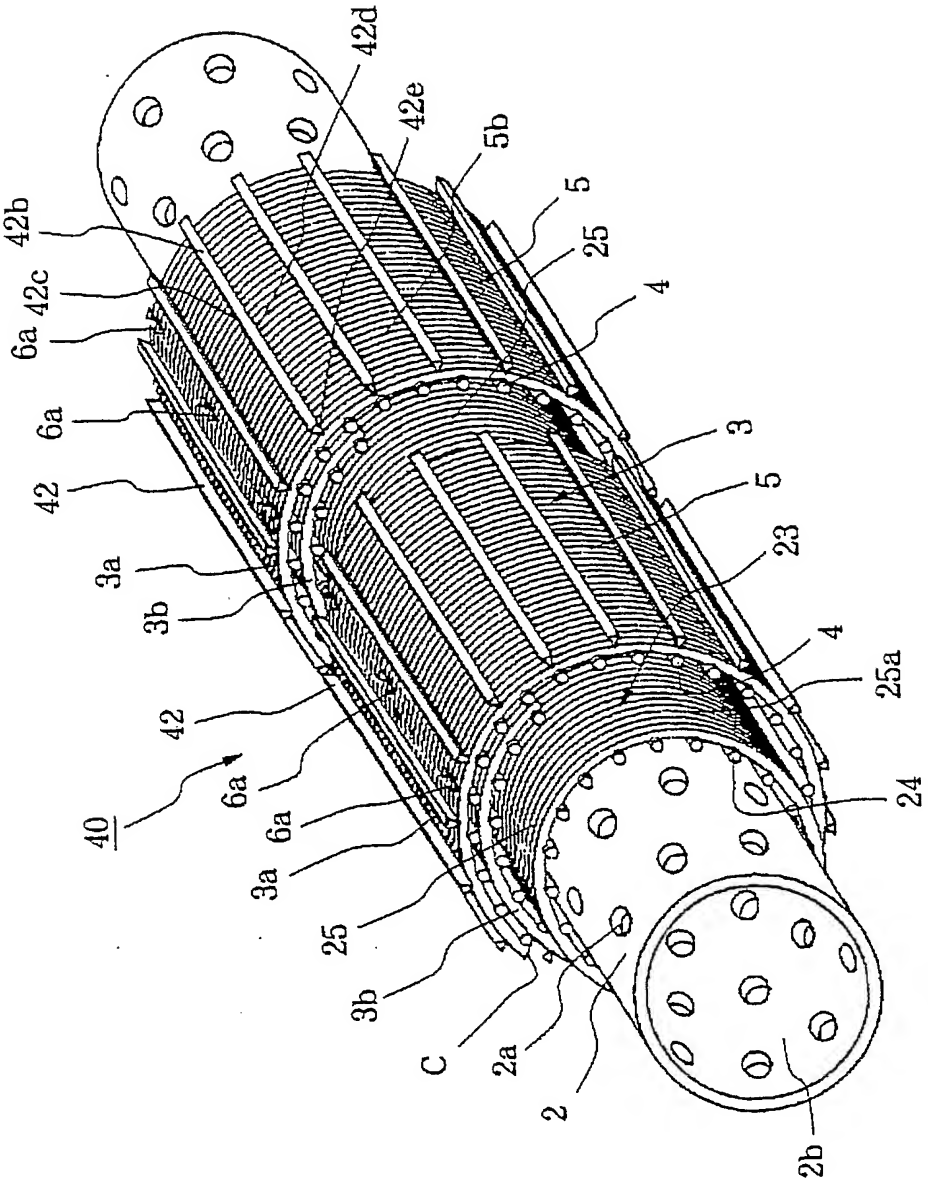


FIG.15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6a
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3a
25
3b
C
2a
2
2b

FIG.16

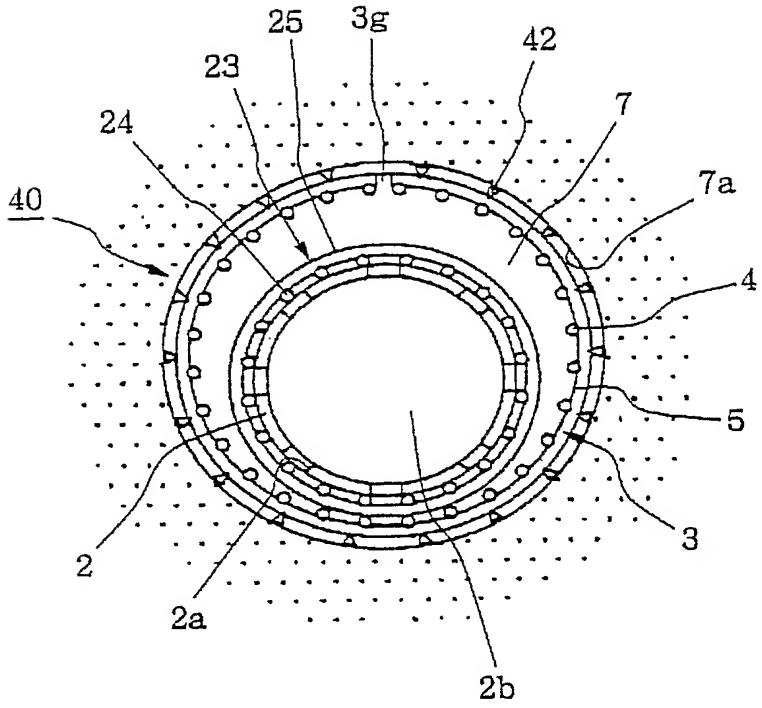

FIG.17

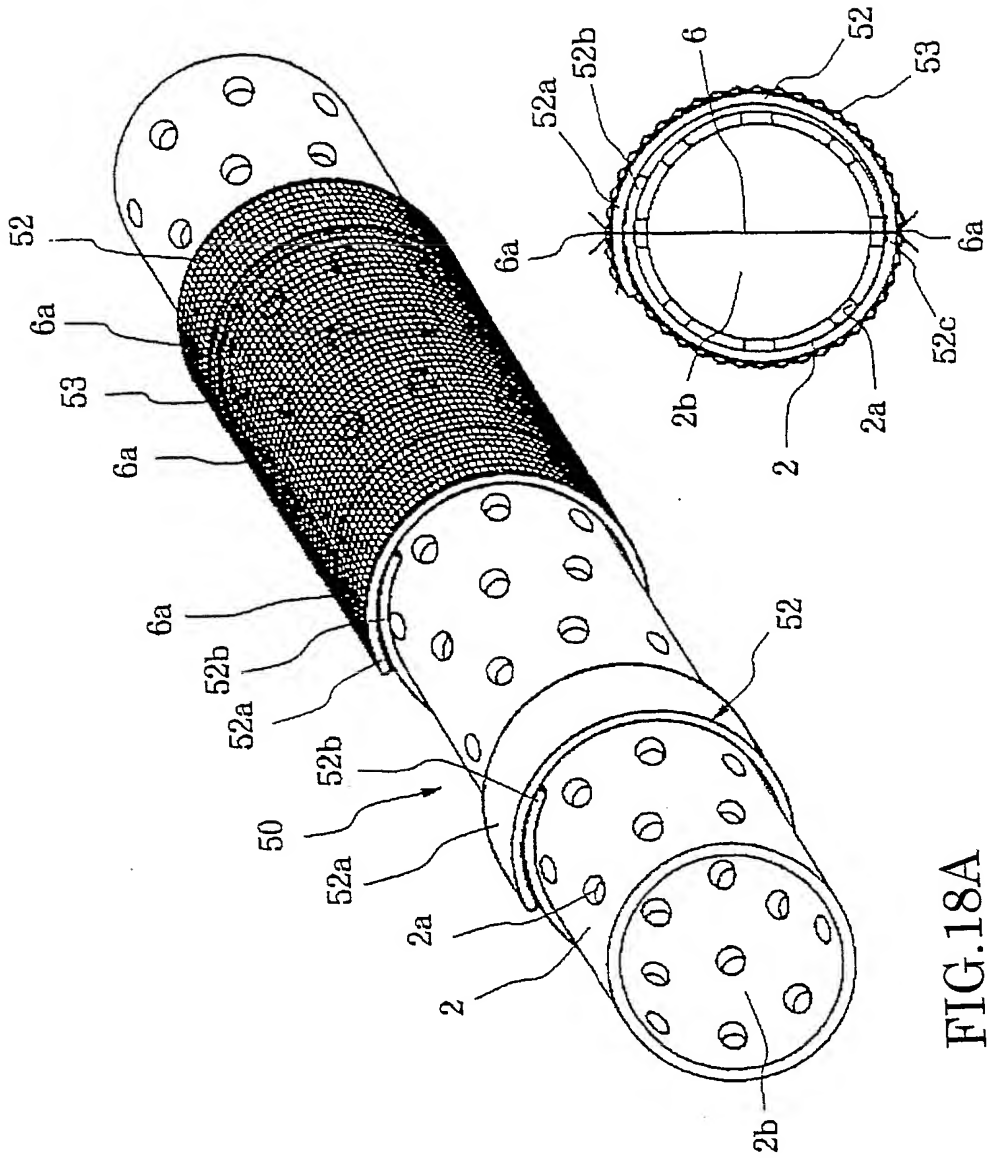

FIG.18A

FIG.18B

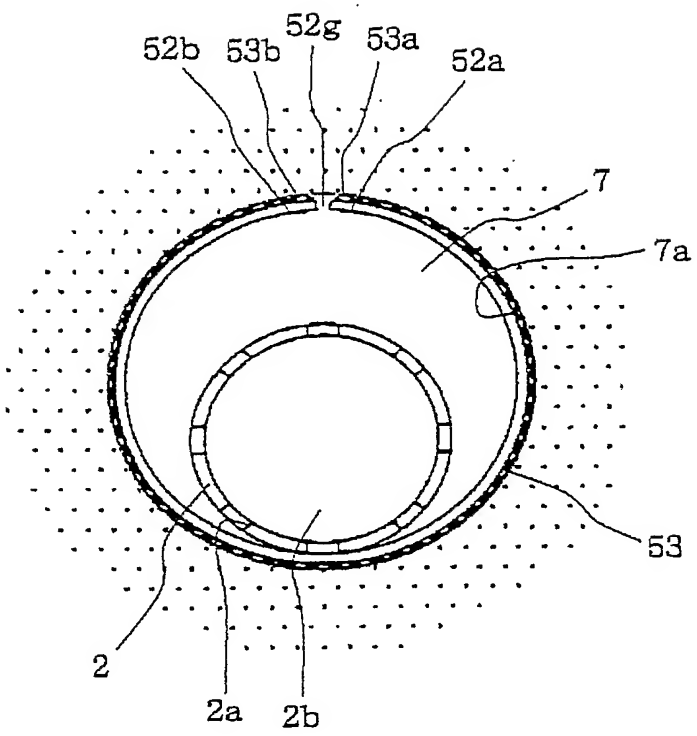

FIG.19

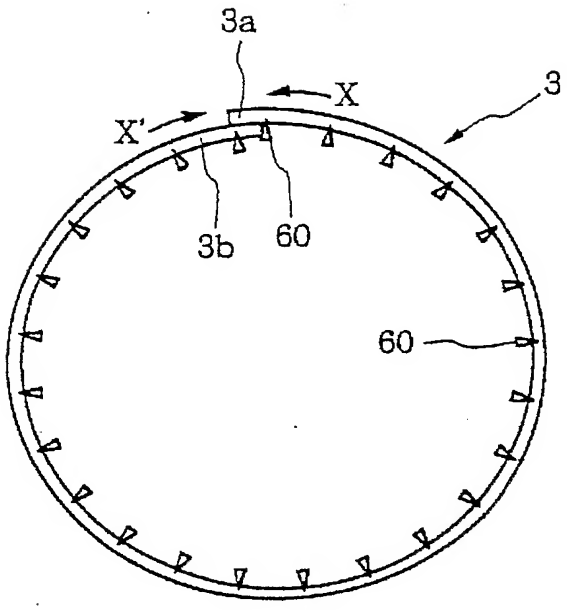

FIG.20

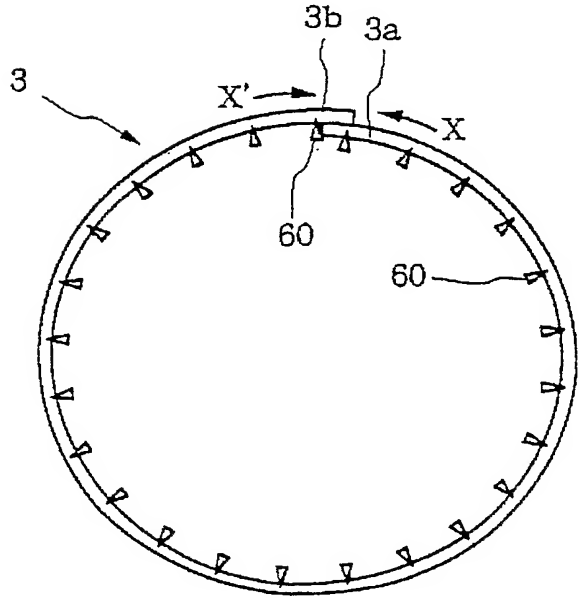

FIG.21

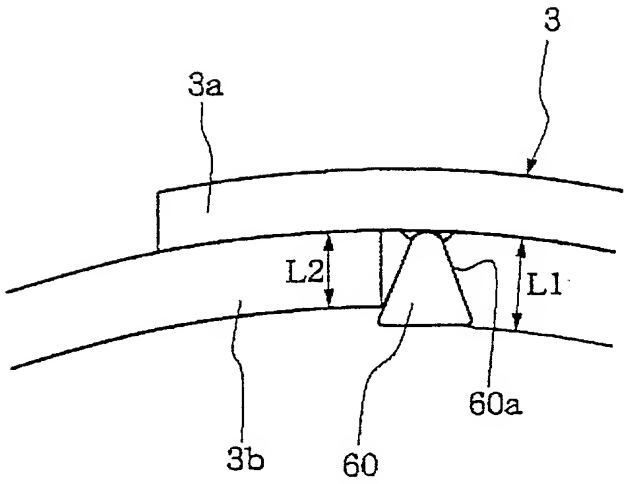

FIG.22

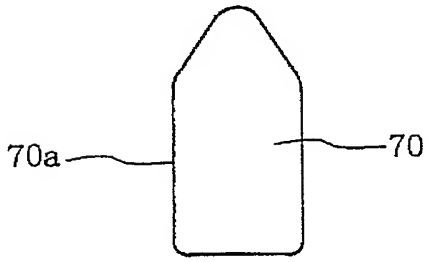

FIG.23

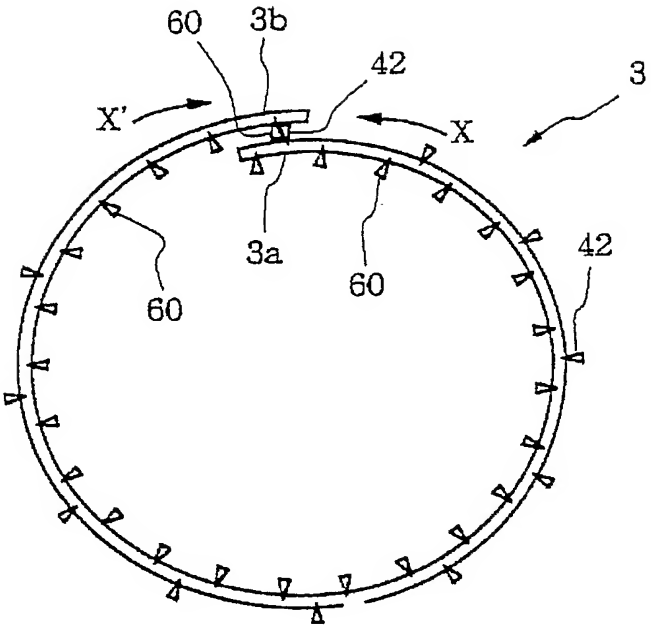

FIG.24

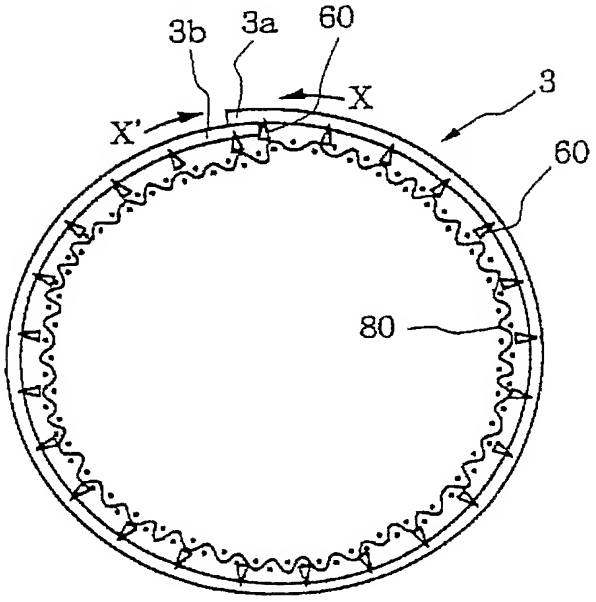

FIG.25

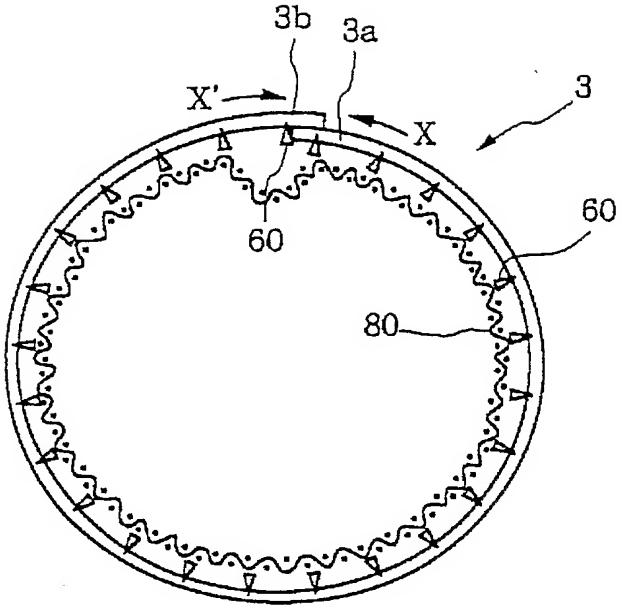

FIG.26

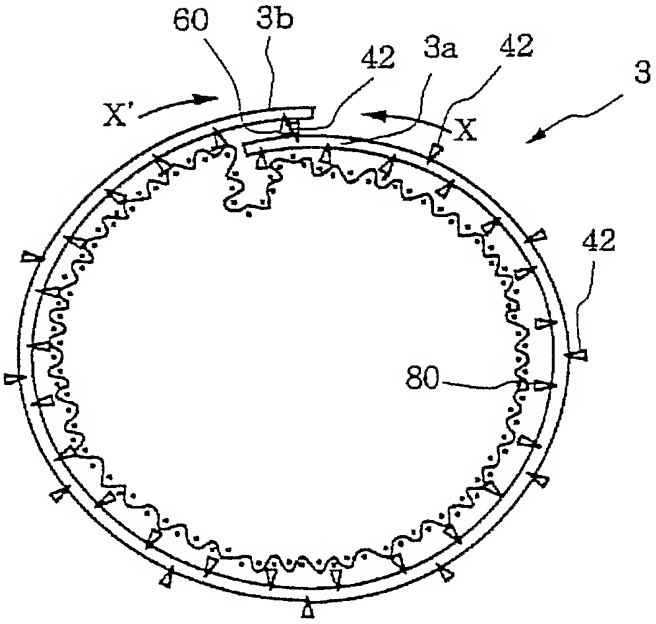

FIG.27

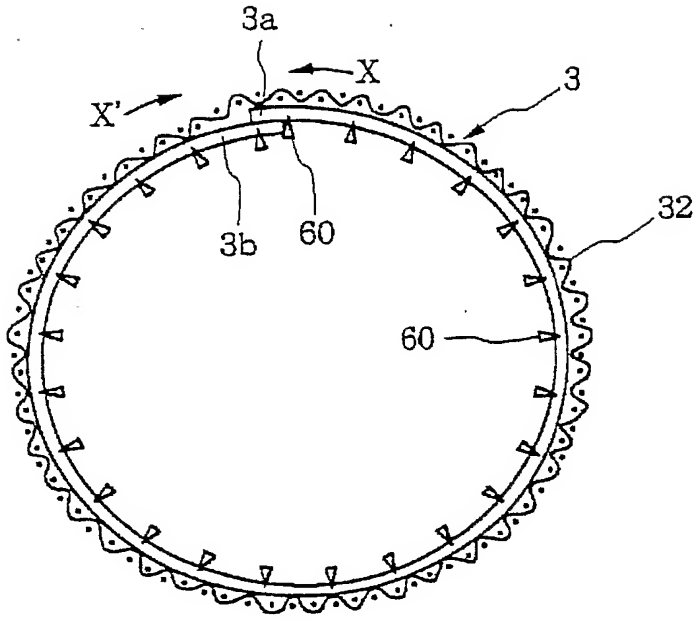

FIG.28

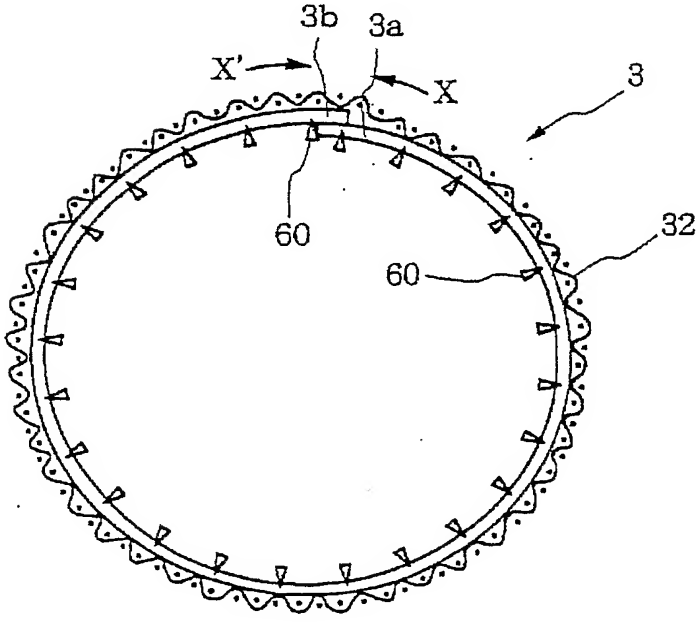

FIG.29

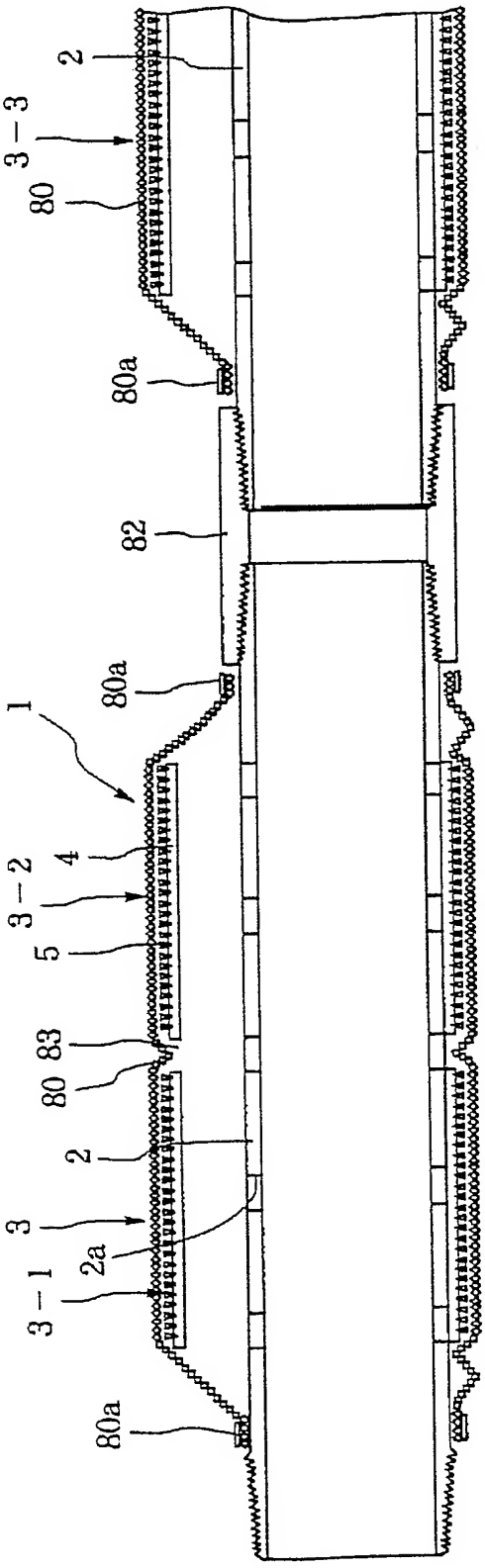

FIG.30

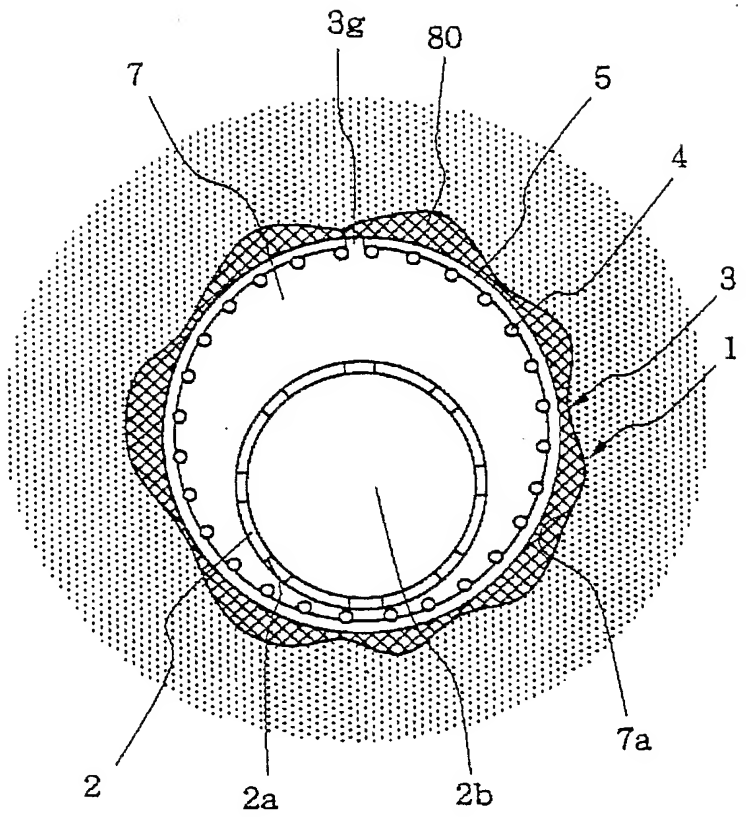

FIG.31

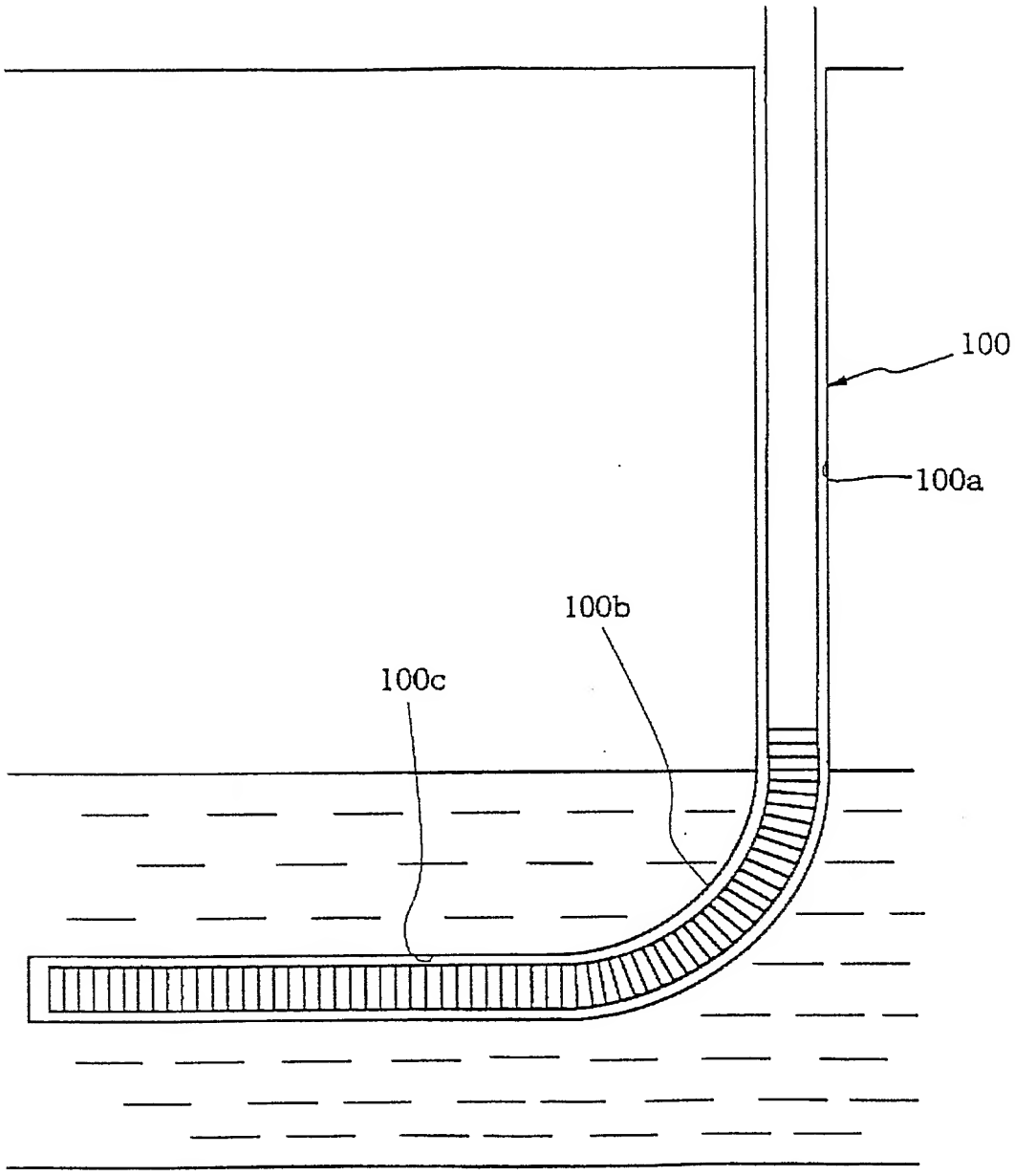

FIG.32

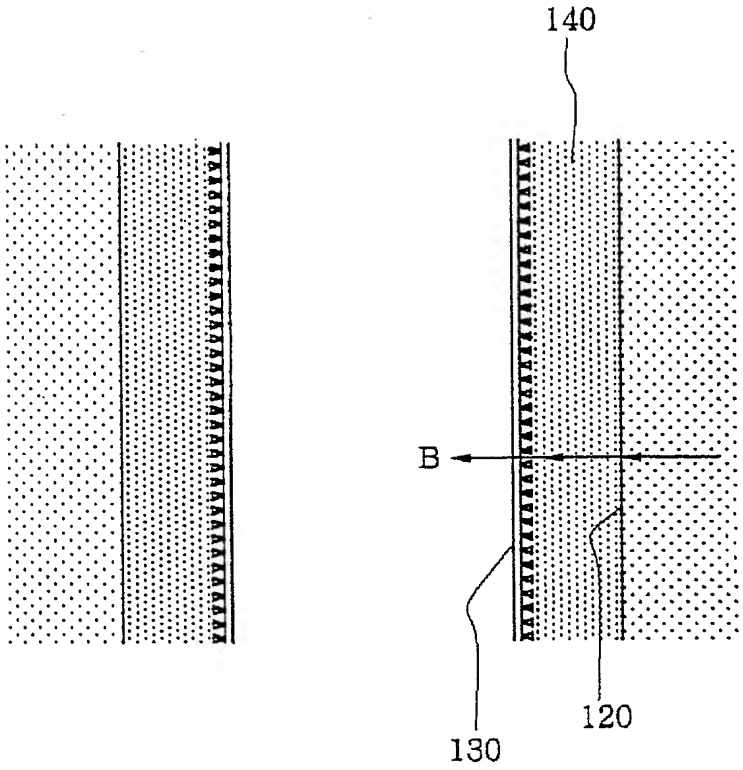

FIG.33

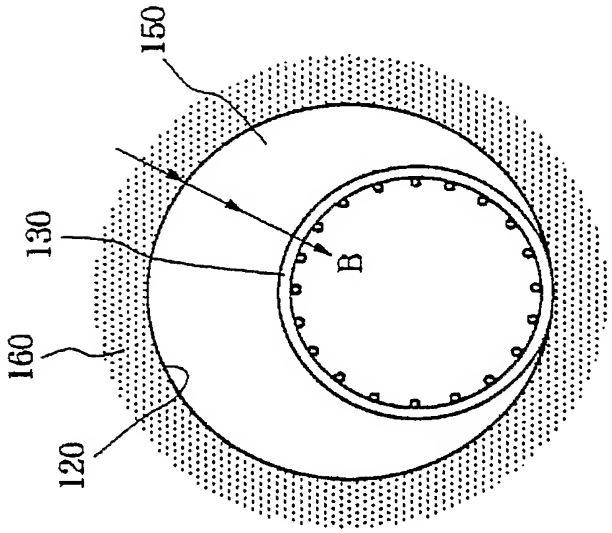

FIG.34B

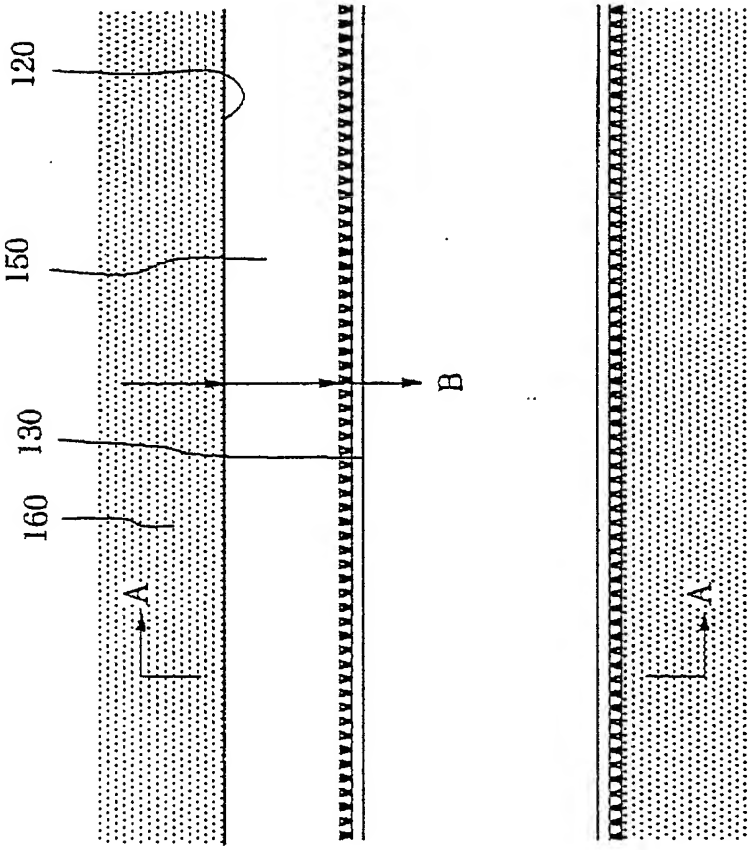

FIG.34A

INTERNATIONAL SEARCH REPORT

International application No
PCT/JP 03/05805

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B43/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 818 403 A (NAGAOKA TADAYOSHI) 4 April 1989 (1989-04-04) column 5, line 16 -column 6, line 59; figures 1,2 ---	1,4,9, 10,13
A	METCALFE P: "EXPANDABLE SLOTTED TUBES OFFER WELL DESIGN BENEFITS" PETROLEUM ENGINEER INTERNATIONAL, HART PUBLICATIONS, US, vol. 69, no. 10, 1 October 1996 (1996-10-01), pages 60-63, XP000684479 ISSN: 0164-8322 figures 3,4 --- -/--	1,4,9, 10,13

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 August 2003	18/08/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Tompouloglou, C

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INTERNATIONAL SEARCH REPORT

International application No
PCT/JP 03/05805

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GILL D S ET AL: "EXPANDABLE TUBE IS NOVEL TOOL FOR DIFFICULT COMPLETIONS, DRILLING" OIL AND GAS JOURNAL, PENNWELL PUBLISHING CO. TULSA, US, vol. 94, no. 23, 3 June 1996 (1996-06-03), pages 37-40, XP000595955 ISSN: 0030-1388 figure 2	1,4,9, 10,13
A	EP 0 527 426 A (NAGAOKA KK) 17 February 1993 (1993-02-17) abstract; figure 1	1,4,9, 10,13

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

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International application No
PCT/JP 03/05805

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